Contract Report 582

Reconnaissance Study of Ground-Water Levels in the Havana Lowlands Area

by Ellis W. Sanderson and Andrew G. Buck
Office of Ground-Water Resources Evaluation & Management

May 1995

Illinois State Water Survey
Hydrology Division
Champaign, Illinois

A Division of the Illinois Department of Energy and Natural Resources

RECONNAISSANCE STUDY

OF

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by

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by
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ABSTRACT

Water-bearing sand and gravel deposits underlying the Havana lowlands region compose an extensive ground-water resource that supplies all of the area's water needs except power generation. Agricultural irrigation is extensively practiced in the area due to the predominance of sandy soils with low moisture-holding capacity and accounts for about 63 to 77 percent of ground-water use depending on the estimate for irrigation. This project established a network of 290 existing wells to measure water levels during Fall 1992 and Spring 1993. Due to record-high ground-water elevations during the summer and fall of 1993, the project was extended to measure water levels in Fall 1993. The data from these three mass measurements were used to produce three maps of the potentiometric surface of the sand and gravel aquifer. The Fall 1992 map was compared to a map developed by Walker et al. (1965) for 1960. This comparison indicates that ground-water levels in Fall 1992 were generally within 5 feet (plus or minus) of the 1960 elevation. This suggests that extensive development of the ground-water resource for agricultural irrigation during the last three decades has not diminished the resource. The present study contributes to the understanding that the sand and gravel aquifer has the capacity both to absorb impacts of concentrated and nearly continuous irrigation withdrawals during drought periods, such as that experienced in 1988 and 1989, and to recover in future years of average and above average precipitation, as in 1993. The project also established a limited long-term observation well network to monitor water levels within the sand and gravel aquifer of the Havana lowlands.

INTRODUCTION

Agricultural irrigation in Mason and southern Tazewell Counties (the Havana lowlands region) grew from about 130 acres in 1954 (Walker, et al., 1965) to an estimated 117,000 acres in 1989 (Bowman, 1991). Such growth has been possible because of the abundant and easily developed ground-water resource that lies beneath the sandy soils of the region. However, there is little documentation about the impact of this extensive irrigation on the region's ground-water resource.

Purpose of Study

Several factors heightened public awareness of the importance of the region's ground-water resource: the severe climatic and agricultural drought in 1988-1989, state legislative initiatives in 1988-1989 relating to ground-water quantity management, and concerns about interference drawdown between irrigation and domestic supply wells. As a result, the newly created Imperial Valley Water Authority (IVWA), through its Board of Trustees, and the Illinois Department of Transportation-Division of Water Resources (IDOT-DWR), expressed interest in further study of the region's ground-water resource. These agencies concluded that the best way to determine the type of study needed was to first evaluate the aquifer's response to the extensive irrigation development over the last three decades. The aquifer response could be documented in a preliminary or reconnaissance study of ground-water levels in existing wells.

Previous Studies

A significant study of the ground-water resources in the Havana lowlands region was published in 1965 by the Illinois State Water Survey and the Illinois State Geological Survey (Walker et al., 1965). The study was undertaken in anticipation of extensive development of the available ground-water resource for agricultural irrigation and industrial supply. The report describes the geologic setting and the hydrologic characteristics of the extensive sand and gravel aquifer and documents the resource development as of about 1960 using estimates of ground-water withdrawals. It also includes maps of the aquifer's potentiometric surface (water table) and provides an estimate of the potential yield of the aquifer system. The report notes that although a huge quantity of water is stored in the aquifer, the potential yield is ultimately limited by the amount of recharge to the aquifer from precipitation.

Bowman and Kimpel (1991) and Bowman et al. (1991) studied irrigation amounts and scheduling practices at representative sites in the region. They found that, in general, irrigation farmers appeared to be applying appropriate amounts of irrigation water at appropriate times during the growing season. For 1989, Bowman and Kimpel (1991) estimated that annual ground-water withdrawals for agricultural irrigation were about 82.7 million gallons per day (mgd) in Mason County and about 23.3 mgd in Tazewell County. During the 1989 growing season (May 1 to August 31), seasonal pumpage in the region was estimated to approach 425 mgd.

The extensive ground-water resource in the region furnishes the water supply for a fish hatchery owned and operated by the Illinois Department of Conservation. The impacts, condition, and capability of the aquifer and well field supplying the hatchery were studied by Visocky and Sievers in a 1992 report.

Acknowledgements

Sponsorship of this project was provided by the Imperial Valley Water Authority, Morris Bell, Chairman; the Illinois Department of Transportation-Division of Water Resources, Gary R. Clark, Chief, Planning and Research Section; and the Illinois State Water Survey. In addition, this project would not have been possible without the willing cooperation and interest of many owners and operators of irrigation and domestic supply wells, who allowed access to their wells for ground-water level measurements. The authors would like to thank each of them.

Curtis R. Benson, Assistant Hydrologist, Illinois State Water Survey, assisted with the field inventory of wells and participated in the mass measurement of ground-water levels. Water Survey staff members Scott C. Meyer, Robert D. Olson, and Mark A. Anliker also participated in the mass measurement of ground-water levels, and George S. Roadcap, Mark A. Anliker, and Sean Sinclair provided consultation for computer mapping efforts. Kris K. Klindworth assisted with database management questions. State Climatologist Wayne Wendland prepared the climate overview.

Word processing to prepare the reproducible copy of this report was done by Patti Hill and Pamela Lovett. The graphics were finalized by Linda Hascall, and editing was done by Sarah Hibbeler.

DESCRIPTION OF STUDY AREA

The Havana lowlands region encompasses all of Mason County and four townships in Tazewell County. The region is roughly triangular in shape and is bounded on the west by the Illinois River, on the south by the Sangamon River and Salt Creek, on the north by the city of Pekin, and on the east by the north-south line dividing Ranges 4 and 5 West (figure 1).

Walker et al. (1965) identified three main physiographic areas within the Havana lowlands: 1) the floodplains of the Illinois, Sangamon, and Mackinaw Rivers and Salt Creek; 2) the wide sand-ridged terraces east of the Illinois River; and 3) the loess-covered Illinoisan drift upland in southeast Mason County. Land surface elevations in the area range from about 433 feet above sea level along the Illinois river near Snicarte in southwest Mason County to nearly 740 feet above sea level in southeast Mason County near Mason City.

Although the Mackinaw River crosses the southern and western portions of Tazewell County, surface drainage within Mason County is poorly developed. The Quiver and Crane Creek Basins, however, have been developed to drain formerly marshy areas in the northern and southern parts of the county.

Climate

Havana's climate exhibits mid-continental characteristics: fairly cold winters and warm, humid summers; most precipitation occurring during the warmer months; and rather large swings in temperature and precipitation from year to year. The 1961-1993 average high temperature is 33 °F for January and 88°F for July, with the average minimum being about 20°F lower. The warmest temperature of record is 106°F and the coldest is -26°F. Average annual precipitation is 37.24 inches, with an average of 6.17 inches occurring from December through February, and 11.44 inches from June through August.

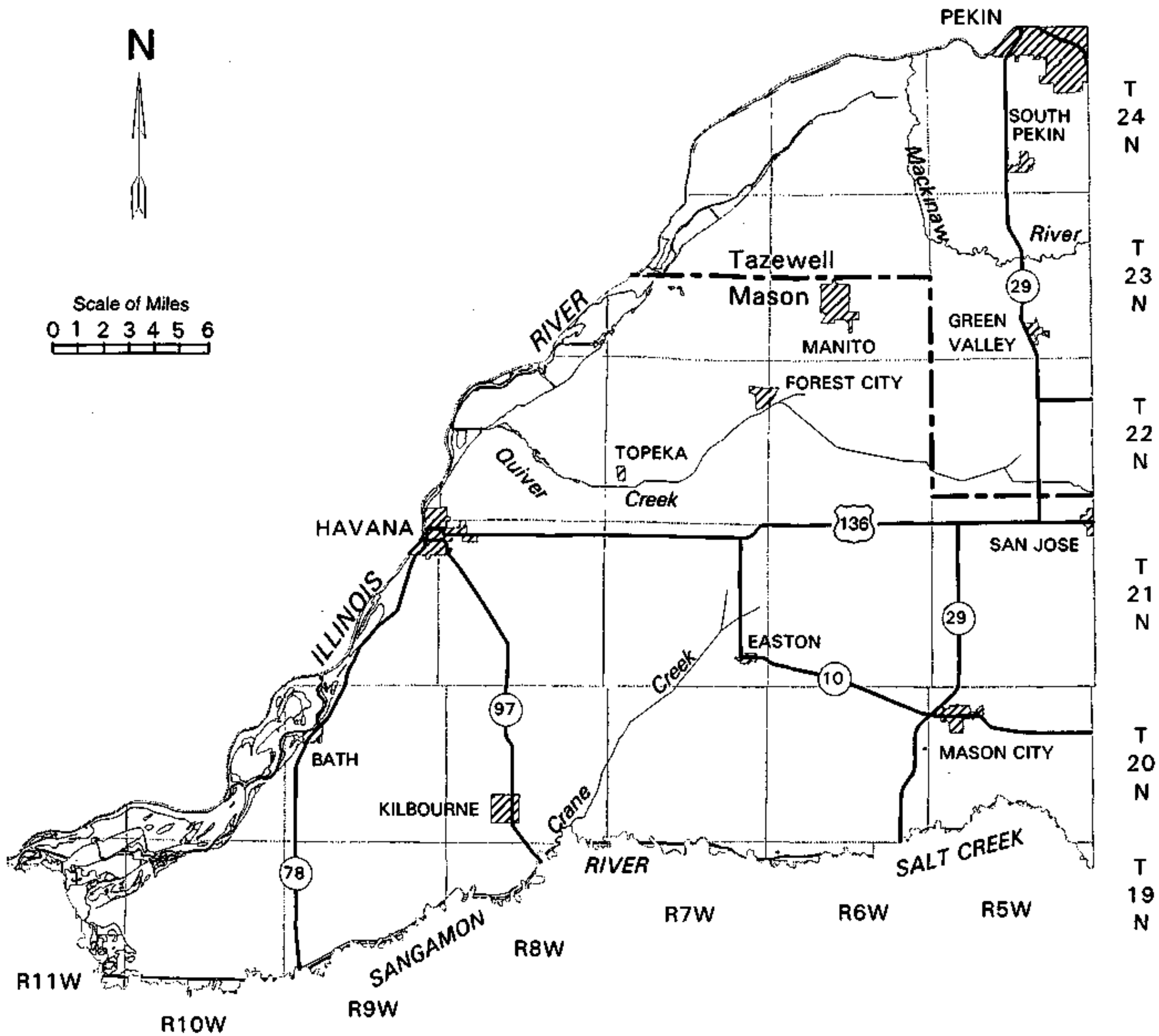

Figure 1. Location of the study area

The wettest and driest years since 1948 occurred in the last six years. The wettest was 1993 with 60.51 inches, 22.19 inches of which fell from June through August. The driest year for the same interval was 1988 with only 23.52 inches, 4.47 inches from June through August.

Soils

The soils in the Havana lowlands are generally characterized by their low moisture-holding capacities. Fehrenbacher et al. (1984) recognized four soil associations in the area. Soils of the Oakville-Lamont-Alvin, Sparta-Dickinson-Onarga, and Plano-Proctor-Worthen soil associations were formed in sandy glacial outwash, sandy alluvium, or sandy aoelian material, and typically exhibit moderate to low water-holding capacities. Soils of the Jasper-LaHogue-Selma soil association were formed under grass in varying thicknesses of silty or loamy sandy deposits, and typically exhibit moderate moisture-holding capacities. Crop stress, fertility management, and wind erosion pose significant problems for crop cultivation on soils in much of the Havana lowlands. But the high permeabilities of these soils facilitate rapid precipitation recharge to the underlying sand and gravel aquifer.

Human Activity

The predominant economic activity in the 700-square-mile study area is crop farming. Irrigation of crops is of increasing importance in the area. In 1989, nearly 117,000 acres were estimated to be irrigated (Bowman, 1991); by 1993, more than 1,200 irrigation systems, primarily center pivots, were in use irrigating approximately 108,000 acres (Rockford Map Publishers, 1993; Gary Clark, personal communication, 1993). Irrigated crops include field corn, seed corn, popcorn, soybeans, winter wheat, and numerous vegetable crops. Mason County has a population of 16,269. With a population of 3,610, Havana, the county seat, is the largest town in the county. The largest town in the Tazewell County portion of the study area is South Pekin, with a population of 1,184. All population data are from the 1990 census.

HYDROLOGY

Ground water is derived from that portion of precipitation that seeps into the ground. The water infiltrates the connected open spaces between soil and rock particles, percolating downward to the point where all available openings in the earth materials are filled, or saturated, with water. Ground water is defined as the water in this zone of saturation. Saturated earth materials that have interconnected openings large enough to store and transmit water to wells in usable quantities are called aquifers.

Aquifer

The productive sand and gravel aquifer underlying the Havana lowlands region originated as a Pleistocene alluvial deposit at the site of the confluence of the ancient

Mississippi River, which was roughly coincident in position with the present lower Illinois River valley, and the ancient preglacial drainageway system now identified as the Teays valley system (Melhorn and Kempton, 1991). In east-central Illinois, the Teays valley is known as the buried Mahomet bedrock valley. The ancient Teays valley system, a series of interconnected valley segments, at various times drained portions of the Midwest extending as far east as West Virginia. The energy of the preglacial drainage and advances of the glacial ice eroded valleys in the bedrock surface, and their confluence at the Havana lowlands region was marked by a broad lowland. Meltwater from Pleistocene glaciers supplied abundant sand and gravel to the ancient Mississippi River valley and the Teays-Mahomet valley system, slowly filling the valleys with sediment. The Teays valley system was abandoned during an early pulse of Pleistocene glaciation, which subsequent glacial advances buried under a thick blanket of comparatively fine-grained glacial sediment, known as glacial drift. Walker et al. (1965) provide a detailed discussion of the origin, composition, and distribution of the Havana lowlands aquifer.

The aquifer consists of sand and gravel deposits of various origins with the total saturated thickness in 1960 ranging from less than 60 feet near the Illinois River to as much as 200 feet immediately north of San Jose.

Aquifer Withdrawals

Wells finished in this sand and gravel aquifer supply all of the area's water needs except cooling for power generation, which uses Illinois River water. Agricultural irrigation is extensively practiced in the area due to the predominance of sandy soils with low moisture-holding capacity. In 1960, only 11 irrigation systems were in use (Walker et al., 1965). By 1993, more than 1,200 systems were in use irrigating approximately 108,000 acres (Rockford Map Publishers, 1993; Gary Clark, personal communication, 1993). Walker et al. (1965) estimated regional irrigation withdrawals for 1959 and 1960 to average about 0.25 mgd per year. The ground-water withdrawals increased to about 106 mgd for 1989, as estimated by Bowman and Kimpel (1991). It should be noted that 1989 was a drought year with higher than average ground-water withdrawals.

For 1986, Kirk (1987) indicated that reported and estimated ground-water withdrawals totaled 54.322 and 32.581 mgd, respectively, in Mason and Tazewell Counties (table 1). Withdrawals for public systems totaled 0.899 mgd and 13.117 mgd, respectively, and industrial withdrawals totaled 1.093 and 6.511 mgd, respectively. Ground-water withdrawals for fish and wildlife were reported to be 8.191 mgd in Mason County, most of which was used by the Jake Wolf Memorial Fish Hatchery, and less than .001 mgd in Tazewell County. Kirk's estimates of irrigation withdrawals in 1986 were 43.299 mgd in Mason County and 11.391 mgd in Tazewell County.

Estimates of irrigation withdrawals in 1989 were made by Bowman and Kimpel (1991) on the basis of data collected during that study. These estimates are 82.7 mgd and 23.3 mgd, respectively, in Mason and Tazewell Counties. The importance of agricultural irrigation in these counties is reflected in the 1989 estimates of irrigation

Table 1. Havana Lowlands Ground-Water Use, 1986

	County	
Use category	*Mason (mgd)*	*Tazewell (mgd)*
Public+	0.889	13.117
Self-supplied industry+	1.093	6.511
Fish and wildlife+	8.191	0.001
Rural+	44.139	12.953
Irrigation (1986 estimates)+	43.299	11.391
Irrigation (1989 estimates)++	82.700	23.300
Totals		
(1986)+	54.322	32.581
(with 1989 irrigation estimates)	93.713	44.491

+*From Kirk, 1987*
++*From Bowman and Kimpel, 1991*

ground-water use, which amount to about 88 percent of total daily ground-water use in Mason County and about 52 percent of total daily ground-water use in Tazewell County (using 1986 withdrawals for other use categories). The 1986 and 1989 irrigation withdrawals cannot be compared because of different estimation methodologies used by Kirk and by Bowman and Kimpel.

Actual daily irrigation ground-water use during the growing season (May 1 to August 31), the period of greatest irrigation, greatly exceeds the figures reflected in table 1. These figures represent averages over a one-year period so that irrigation can be compared to other ground-water withdrawals. Estimates of seasonal irrigation pumpage in the Havana lowlands approached 425 mgd in 1989 (Bowman and Kimpel, 1991).

Recharge from Precipitation

Walker et al. (1965) estimated natural recharge from precipitation on the basis of flow channel delineation and the general character of the soils in the area. They used the map of 1960 ground-water levels to delineate four flow channels (figure 2) and used the following form of Darcy's law to compute representative natural recharge rates for the area.

$$Q = TIL$$

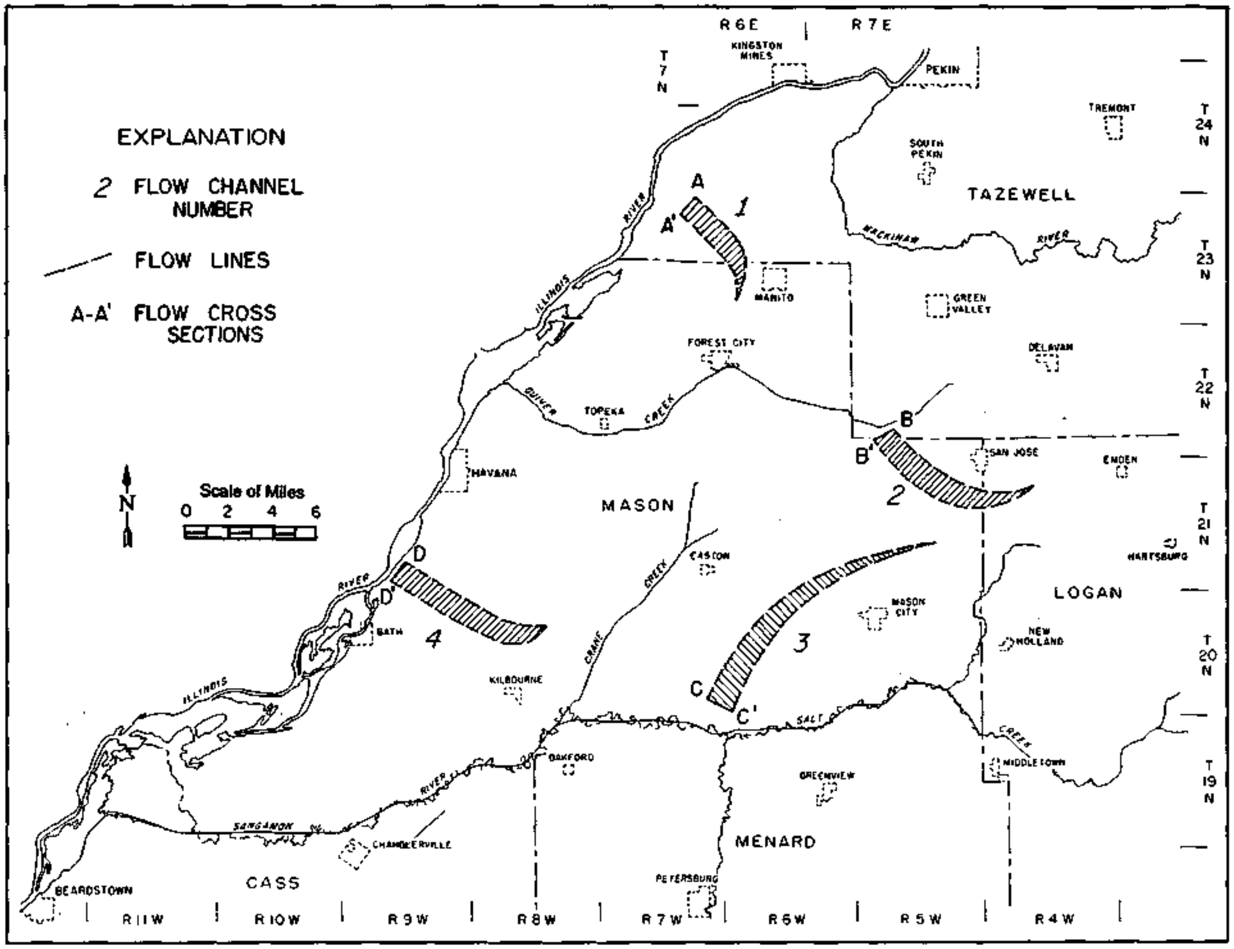

Figure 2. Location of flow channels used to determine recharge rates (from Walker et al., 1965)

where:

Q = quantity of water percolating through a given flow cross section, in gallons per day (gpd)
T = transmissivity, in gpd/foot
I = hydraulic gradient of potentiometric surface at flow cross section, in feet/mile
L = length of flow cross section, in miles

In the western portion of the study area, which has generally sandy soils, recharge rates were estimated to be about 490,000 gpd/square mile (sq mi). In the eastern portion, which contains soils that are more loamy and tend to retard vertical percolation of water, recharge rates were estimated to be about 270,000 gpd/sq mi.

The total precipitation recharge to the extensive sand and gravel aquifer was estimated by Walker et al. (1965) to be about 300 mgd for the region.

Visocky and Sievers (1992) reported results of recharge estimation methodologies used in their study of the well field at the Jake Wolf Fish Hatchery in northern Mason County. By modifying a method described by Stallman (1956), "effective" recharge rates ranging from about 292,000 gpd/sq mi to 507,000 gpd/sq mi were developed for data collected in late 1989 and 1990, a period with above average rainfall. The same flow net methodology used by Walker et al. was used to derive an average recharge value of about 855,000 gpd/sq mi. Visocky and Sievers also reported a water balance method for natural recharge estimation. For 1990, a year with above average precipitation, this water balance method performed by Jean Bowman of the Water Survey yielded an estimate of about 941,000 gpd/sq mi.

Potential Yield

Potential yield is defined as the amount of ground water that can be continuously withdrawn from a reasonable number of wells without creating critically low water levels or exceeding the recharge rate. The water transmitting capability and the water storage capacity of the sand and gravel aquifer in the region are great enough that more ground water could be pumped from the aquifer system than can be recharged by precipitation (Walker et al., 1965). Thus, the potential yield of the sand and gravel aquifer depends on recharge rates rather than on the water-yielding character of the aquifer. Precipitation recharge within the region was estimated by Walker et al. (1965) to be about 300 mgd per year. Further, although the conditions are basically unexplored, they suggested that it might be possible to induce as much as 50 mgd of additional water from the Illinois River with wells located adjacent to the river. Thus, the total potential yield for the region was estimated to be about 350 mgd.

MASS MEASUREMENT WELL NETWORK

This reconnaissance study of ground-water levels focussed on the measurement of water levels in a network of existing wells. The plan was to establish a network of 250 or more existing wells and to measure their water levels during Fall 1992 and Spring 1993. The timing of water-level measurements was chosen to map ground-water levels when they are near their seasonal low (fall) and high (spring) levels. The water-level data collected could be used to construct maps of the ground-water level surface, which could then be compared to the map prepared by Walker et al. (1965) using data collected in 1960. This comparison would be expected to provide a reconnaissance-level evaluation of the response of the ground-water resource to the extensive development for agricultural irrigation.

The network of existing wells was established by conducting a field survey or inventory to determine which existing wells might be suitable for inclusion in the network. This entailed documenting information on their location, measuring-point elevation, and construction features. This documentation would permit others to measure water levels in the mass measurement network wells both as part of this project and in future years as the need occurs.

Field Inventory of Wells (Summer 1992)

The process of inventorying water wells to be included in the network involved both office and field work. Office work conducted prior to the actual field inventory included obtaining topographic maps, county road maps, plat books, telephone books, and related information to help document well locations, measuring-point elevations, and routes of access. Available data for wells in the region were also retrieved from the well information databases being compiled at the Water Survey. Where possible, the wells selected for the network would be those for which a well record was available in Water Survey files. Further, based on previous project experience in the area, it was anticipated that irrigation wells would be the primary target for inclusion in the network. To establish a central repository for the documentation, a form was designed for recording appropriate well information and measurements of ground-water levels.

A press release was sent to the local newspapers to describe the project and to seek well owner/operator cooperation in establishing the network. The Mason and Tazewell County sheriff's offices were notified about the project before the field work began in case rural residents became concerned about the appearance of field staff in their area.

The field work to inventory wells began on May 24, 1992, and concluded on August 24, 1992. The inventory protocol began with contacting irrigation well owners/operators to seek permission to include their well(s) in the network providing there was access at the well head for water-level measurement. If they granted permission for us to. access the well(s), they were asked if they owned or operated other wells and, if so, to locate on a map those wells that might be candidates for the network.

In addition, many well owners/operators were able to assist field staff in contacting other owners/operators in their neighborhood. The name, mailing address, and telephone number of each well owner/operator were recorded to permit future contact.

Once permissions had been obtained, field staff visited each well that was a candidate for the network. First, they determined whether there was suitable access for measurement of the water level and, if possible, they measured the depth to water in the Well using either a chalked steel tape or an electric drop line. The depth to water was recorded on the documentation form along with the information on well construction features, where available. The topographic map was studied to estimate the land surface elevation of the well site, which was then recorded on the documentation form to permit later conversion of depths to water to ground-water level elevations.

The inventory of wells resulted in a mass measurement network of 290 wells. In addition, four stream sites were included in the network to help establish approximate ground-water elevations near principal streams in the area. Table 2 summarizes the number of wells and stream sites by type.

Selected information collected during the office and field inventory of wells was entered into a database to facilitate the manipulation and compilation of the data for the production of the ground-water level maps.

Table 2. Summary of Wells and Surface Water Sites Inventoried

235	irrigation wells
230	active
5	inactive
29	domestic wells
27	active
2	inactive
5	farm wells
4	active
1	inactive
21	observation wells
4	surface water sites
294	Total Sites

Project Database Development

To manage the data collected during the inventory process and the mass measurements of wells, a computerized database was developed to help store, query, and interpret selected data. Paradox®, Version 3.5 (Borland International, Scotts Valley, CA) was chosen as the database software for the study because it provides convenient facilities for creating entry screens, querying the database, and creating reports on the data. Data fields were created for selected information sets collected during the well inventory process and mass measurements. The project database field headings are summarized below:

Well ID Number	Spring 1993 Ground-Water Elevation
USGS Quad. Map	Fall 1993 Ground-Water Elevation
Owner/Operator	Well Use
Well Depth	Measuring Point
Inventory Ground-Water Elevation	X Lambert Coordinate
	Y Lambert Coordinate
Inventory Date	Legal Location
Land Surface Elevation	Owner/Operator Address
Inventory Depth to Water	Fall 1992 Ground-Water Elevation

The project database software allowed queries on specific data for various uses. One example of the way in which the database was accessed was in the construction of the Fall 1992 potentiometric surface map. The x-coordinate, y-coordinate, and Fall 1992 ground-water elevations (x,y,z) fields were queried for each well inventoried and were output to an ASCII-delimited computer file. This data set was then imported into a contouring software program, which was used to construct the Fall 1992 potentiometric surface maps. The project database will also provide convenient access to the collected data for future projects.

Distribution of Wells

The goal of the well inventory was to achieve a spatial coverage in the region of nearly one well per 2 sq mi, or about 14 to 18 wells per a 36-sq mi township. There was an effort to achieve a somewhat higher density of inventoried wells in western Mason and Tazewell Counties, where most of the agricultural irrigation takes place and where ground-water elevation changes are greater near the Illinois River, than in eastern portions of the counties where there are few irrigation wells. Thus, in the eastern part of the region, domestic and farm wells rather than irrigation wells were included in the network. The number of these wells is indicated in table 2, and the spatial distribution of the network wells is shown in figure 3. Appendix A lists the legal location, owner/operator, and the water-level data for each well in the network.

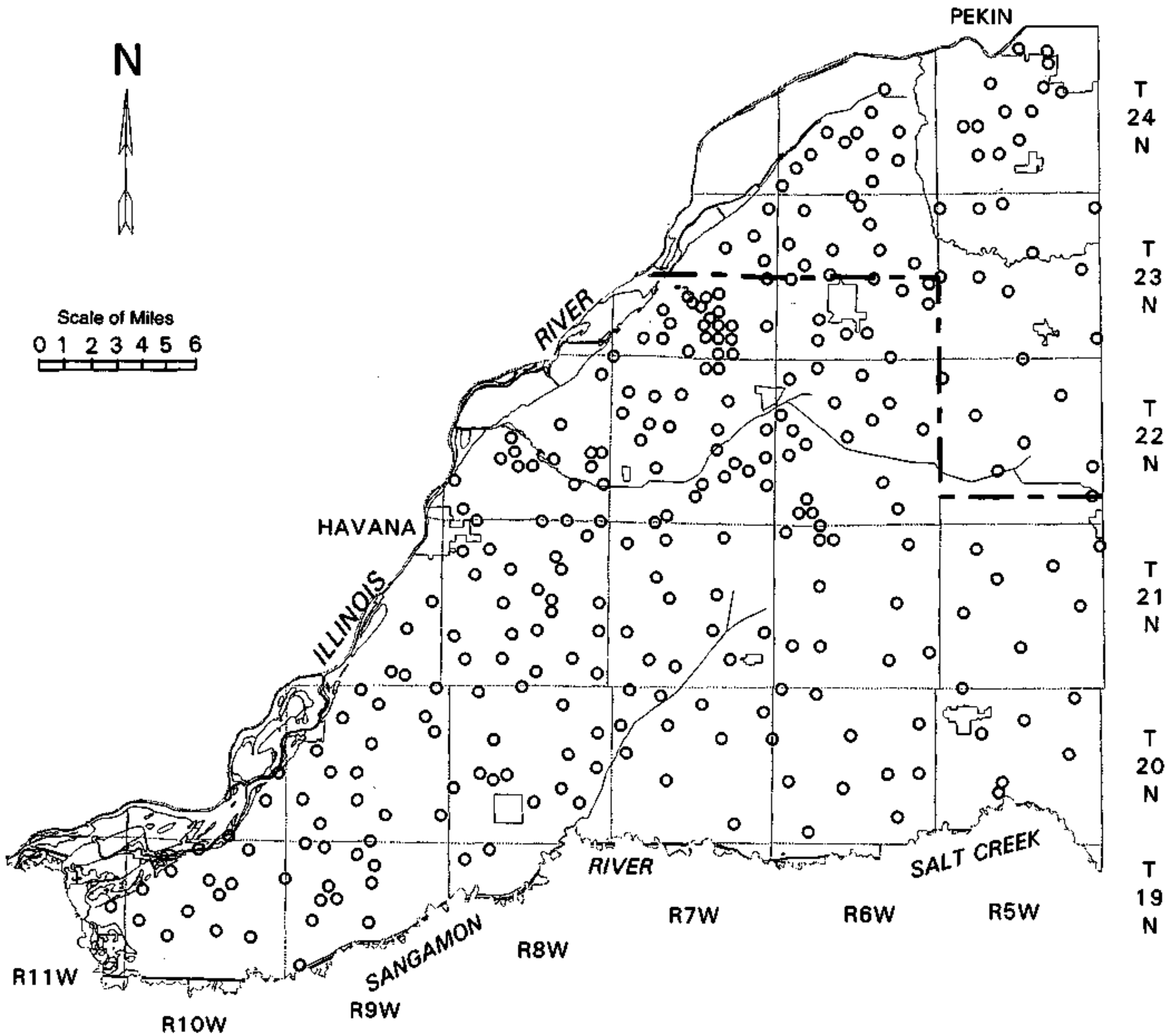

Figure 3. Location of wells included in the mass measurement network

Timing of Mass Measurements

Ground-water levels fluctuate seasonally in response to changes in the amount of water stored in the aquifer. This change in storage is effected by the direct recharge from precipitation, evapotranspiration, withdrawals from wells, discharge to streams, and changes in surface water stage. Under natural conditions, ground-water levels in the Havana lowlands recede in the late spring, summer, and early fall, when discharge by evapotranspiration and by ground-water runoff to streams is greater than recharge from precipitation. Well water levels begin to recover in late fall when evapotranspiration losses are small and conditions are favorable for rainfall to replenish depleted soil moisture and later to percolate to the water table. The rise of water levels is especially pronounced in the wet spring months when the ground-water reservoir receives most of its annual recharge. The high and low points of the annual cycle of water levels occur at different times from year to year, depending in large part on the seasonal and areal distribution and intensity of rainfall.

Superimposed on the annual cycle are changes in water levels caused by pumping. Pumping lowers water levels in the vicinity of the well until 1) a hydraulic gradient is established from a source of recharge to the pumped well sufficient to bring from the recharge area the amount of water being pumped, 2) sufficient water is diverted from an area of discharge to balance pumpage, or 3) a combination of increased recharge and diverted discharge balances the pumpage.

The magnitude of these water-level changes in the southwestern part of the Havana lowlands has been monitored since March 1958 in an inactive domestic well near Snicarte (Section 11.8b, T.19N., R.10W., Mason County). The hydrograph for the period of record for this well is shown in figure 4. The data from this long-term record helped to determine when ground-water levels would be near their seasonal low and high levels.

Ground-water levels in wells tapping the sand and gravel aquifer associated with the Havana lowlands region of Mason and Tazewell Counties were measured on three separate occasions: Fall 1992, Spring 1993, and Fall 1993 during the dates given in table 3. These water-level measurements have been used to prepare maps that represent the potentiometric surface of the unconfined sand and gravel aquifer. The Fall 1992 and Spring 1993 mass measurements of wells were conducted as part of a reconnaissance study to provide a benchmark characterization of regional ground-water levels. The fall and spring time periods were chosen to map ground-water levels when they are near their seasonal low and high levels, respectively. The Fall 1993 mass measurement of ground-water levels was added to the reconnaissance study when record-setting precipitation and Illinois River flood stages in summer and early fall caused high ground-water levels with resultant surface flooding. The surface flooding had considerable socioeconomic impacts on much of the Havana lowlands region. The measurements during Fall 1993 were taken when much of the Havana lowlands region was affected by these extremely high (perhaps all-time record-high) ground-water levels.

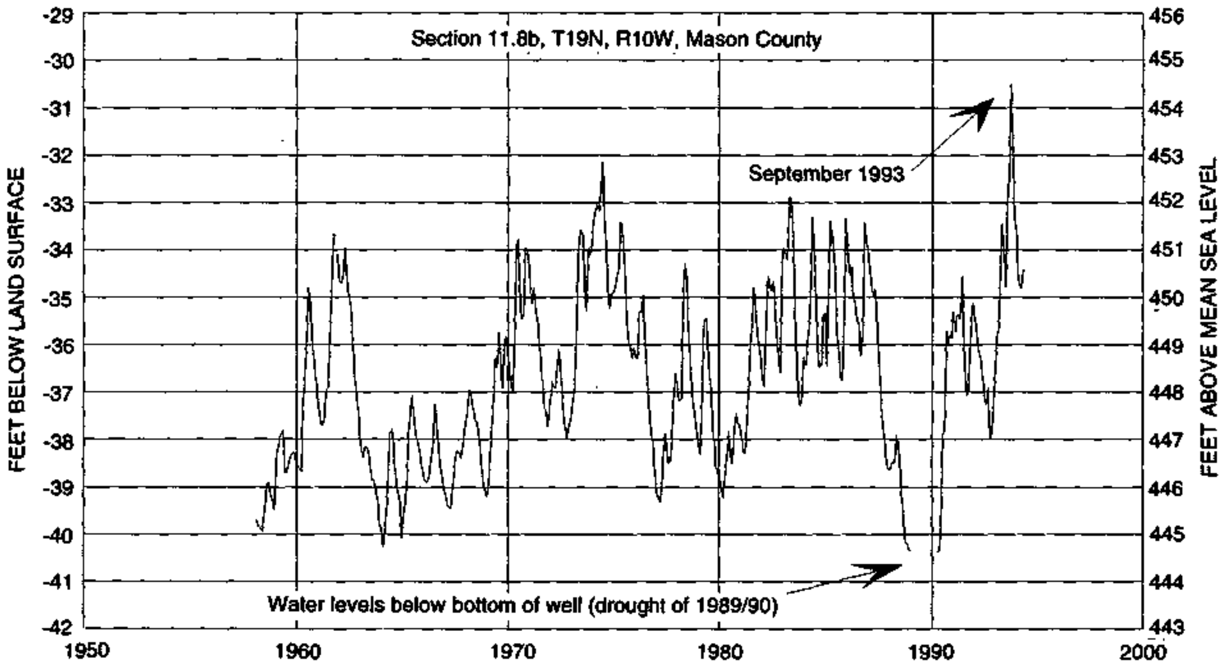

Figure 4. Long-term hydrograph of ground-water levels in the Snicarte observation well

Table 3. Dates of Mass Measurements

Measurement period	*Dates*
Fall 1992	August 31 - September 4
Spring 1993	May 24 - May 26
Fall 1993	September 27 - October 1

The three mass measurements involved taking depth-to-water readings within a one-week period in as many of the 290 irrigation, industrial, domestic, and observation wells that compose the network as possible. The readings were taken while the wells were not pumping. The depth-to-water measurements were then subtracted from the land surface elevation (estimated from a topographic map) to determine an estimated ground-water level elevation above mean sea level (msl).

POTENTIOMETRIC SURFACE OF THE AQUIFER

Ground water contained in aquifers has an associated "head" or "pressure" that is exhibited by the water level that stands in a well tapping that aquifer. If an aquifer is extensively tapped by wells for water supply, the elevations of water levels in those wells can be plotted on a map and contoured. The resulting surface as defined by the contoured map is called a *potentiometric surface*. A potentiometric surface map of an aquifer provides an indication of the directions of ground-water movement in the aquifer. A series of potentiometric surface maps, ideally coupled with ground-water withdrawal data, can monitor whether an aquifer is being overdeveloped on a regional basis.

1960 Potentiometric Surface Map

In the study by Walker et al. (1965), a potentiometric surface (water table) map of ground-water levels was prepared (figure 5) from measurements taken in 103 wells. With the exception of the area immediately south of Pekin, contours of the potentiometric surface had not been distorted nor the elevation affected by pumpage.

Methodology for Map Development

The potentiometric surface maps in this report were constructed by contouring the ground-water level data using the computer software program SURFER®, Version 4 (Golden Software, Golden, CO). Additional data points were added to represent surface water elevations along the Illinois and Sangamon Rivers where ground water and surface water are in direct hydraulic connection. The potentiometric contour maps were then imported into the computer software program AutoCAD®, Release 12 (Autodesk, Inc., Sausalito, CA) from which a base map of the study area was developed. This same method was used in constructing ground-water level change maps, which were developed

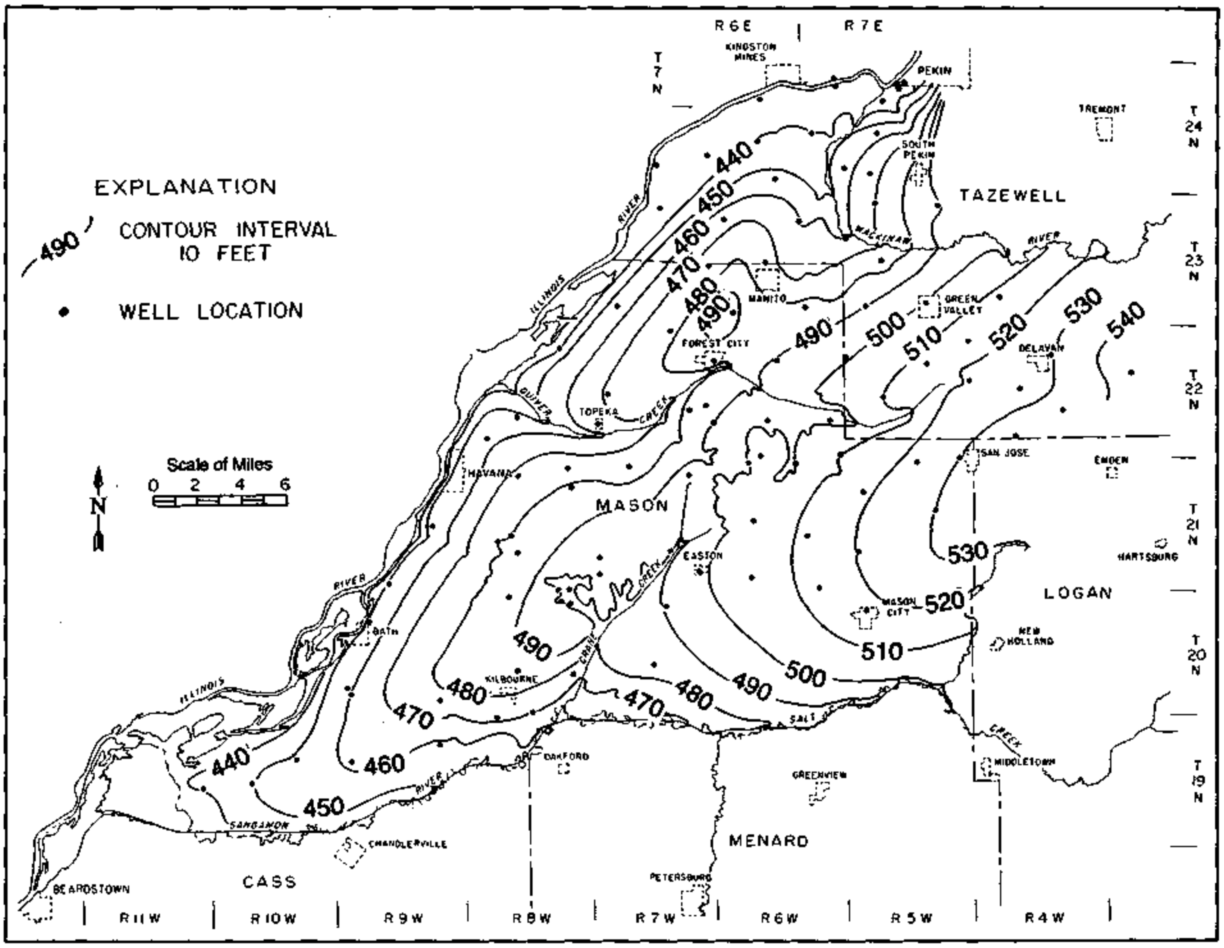

Figure 5. Approximate elevation of the Havana lowlands water table in 1960 (from Walker et al., 1965)

to show the elevation changes in the potentiometric surface between 1960 and Fall 1992, Fall 1992 and Spring 1993, and Fall 1992 and Fall 1993.

Surface water elevation data points for the Illinois River were based on data from the pool level at Lower Peoria Lock and Dam at river mile 157.7 and data from the U.S. Geological Survey (USGS) gage at Kingston Mines. Surface water elevations along the Sangamon River for the Fall 1992 potentiometric surface map were taken from USGS topographic map elevations. For the Spring 1993 and the Fall 1993 potentiometric surface maps, Sangamon River elevations were estimated by calculating changes in ground-water elevations near the river and then adding those changes to the Sangamon River elevations used for the Fall 1992 map.

Fall 1992 Potentiometric Surface Map

The Fall 1992 potentiometric surface map (figure 6) was created using 286 water-level measurements. These measurements were taken from August 31, 1992, through September 4, 1992, in order to document ground-water levels in the Havana lowlands when they are near their seasonal low levels. This typically occurs from September to November, according to historical data from the Snicarte observation well located in Section 11.8b, T.19N., R.10W., Mason County.

The two dominant hydrologic features of the Havana lowlands region are the Illinois River, which marks the western boundary of the study area, and the Sangamon River, which delineates the southern edge of the study area. Both the Illinois and Sangamon Rivers, as well as some smaller creeks, are in direct hydraulic connection with the sand and gravel aquifer system in this region. The potentiometric level of the ground water approaches the elevation of the surface water immediately adjacent to the stream. The two rivers serve as the major discharge areas for ground water in the region, as evidenced by the way in which the potentiometric contours generally parallel the river and by the potentiometric gradient of the ground water, which shows movement toward the river.

Another hydraulic feature of the Havana lowlands area is a regional ground-water divide (shown in figure 6). A ground-water divide can be characterized as an imaginary plane of separation marking the boundary between two ground-water basins or dividing the ground water that flows naturally in one direction from the ground water that flows in another direction. In the Havana lowlands area, a regional ground-water divide separates the ground water into two basins. This divide runs nearly parallel to and approximately 4 to 6 miles north of the Sangamon River. Ground water south of this boundary discharges into Crane Creek, Salt Creek, or the Sangamon River, while ground water north of the divide flows in a west-northwesterly direction and discharges to Quiver Creek, the Mackinaw River, or the Illinois River. The ground-water basin to the north of the divide encompasses the majority of the ground water in the Havana lowlands region.

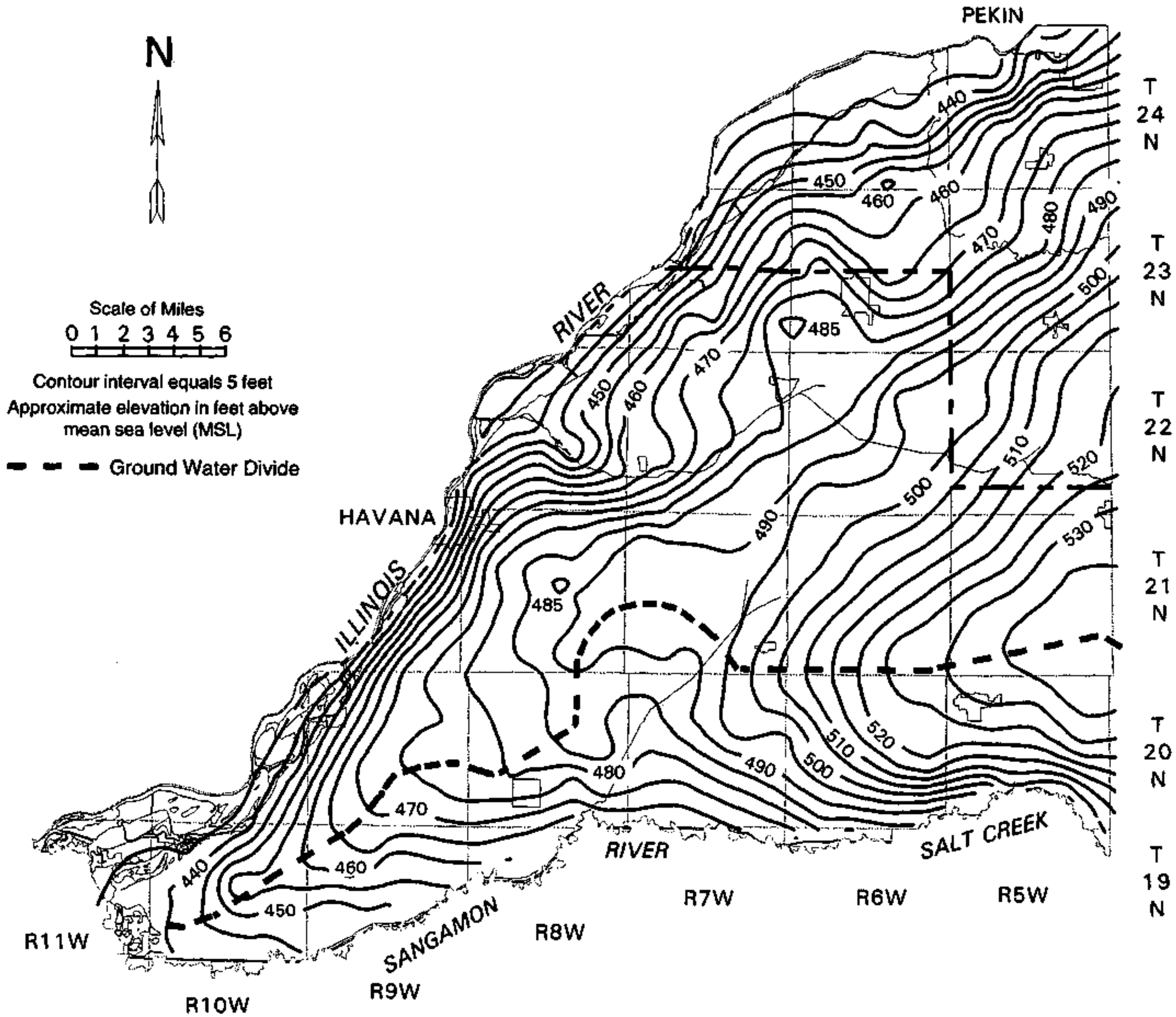

Figure 6. Potentiometric surface of the Havana lowlands sand and gravel aquifer, Fall 1992

The potentiometric surface of the north ground-water basin is highest on the eastern margin of the study area south of the village of San Jose and northeast of Mason City. The potentiometric surface of the ground water in the sand and gravel aquifer in this area was about 535 feet msl during Fall 1992. The surface is lowest along the Illinois River where ground-water discharges to the surface water. During the Fall 1992 mass measurement, the elevation of the Illinois River was approximately 432 feet msl, indicating that the ground-water gradient averages about 4.3 feet per mile for the span from northeast of Mason City to the Illinois River near Havana.

As in the north ground-water basin, the potentiometric surface in the south ground-water basin is highest at about 535 feet msl. The potentiometric surface along the Sangamon River is at approximately 504 feet msl near the intersection of the river and the eastern margin of the study area to about 431 feet msl at the confluence of the Illinois and Sangamon Rivers. The potentiometric surface map indicates a gradient of about 4.3 feet per mile from the area northeast of Mason City south to the Sangamon River. There is a gradient of approximately 2.7 feet per mile in the south ground-water basin from the area northeast of Mason City to the confluence of the Illinois and Sangamon Rivers.

The potentiometric surface contours become closer together as they approach the Illinois and Sangamon Rivers, indicating an increase in the hydraulic gradients of the ground water as it nears its discharge point. There is a gradient of about 30 feet per mile from the eastern edge of the city of Havana to the Illinois River.

Spring 1993 Potentiometric Surface Map

The Spring 1993 potentiometric surface map (figure 7) was created using 283 water-level measurements taken from May 24 through May 28, 1993. The mass measurements were conducted at the end of May to document ground-water levels near their seasonal high levels. Historical data from the Snicarte observation well located in the southwestern portion of the study area indicate that these annual high ground-water levels usually occur during April to June of any given year.

The map was developed using the methodology described above. Illinois River water levels were approximately 8 feet higher during Spring 1993 than during Fall 1992 mass measurements of ground-water levels. An elevation of about 440 feet msl was used for the Illinois River near Pekin, Illinois, while an elevation of 504 feet msl was determined for the Sangamon River near the eastern margin of the study area. For the confluence of the Illinois and Sangamon Rivers, which marks the southwestern corner of the study area, an elevation of about 439 feet msl was calculated.

The basic configuration of the Spring 1993 ground-water elevation contour map compares closely to the Fall 1992 map. The Spring 1993 map shows the ground-water divide approximately parallel to and north of the Sangamon River, similar to its location as shown on the Fall 1992 map.

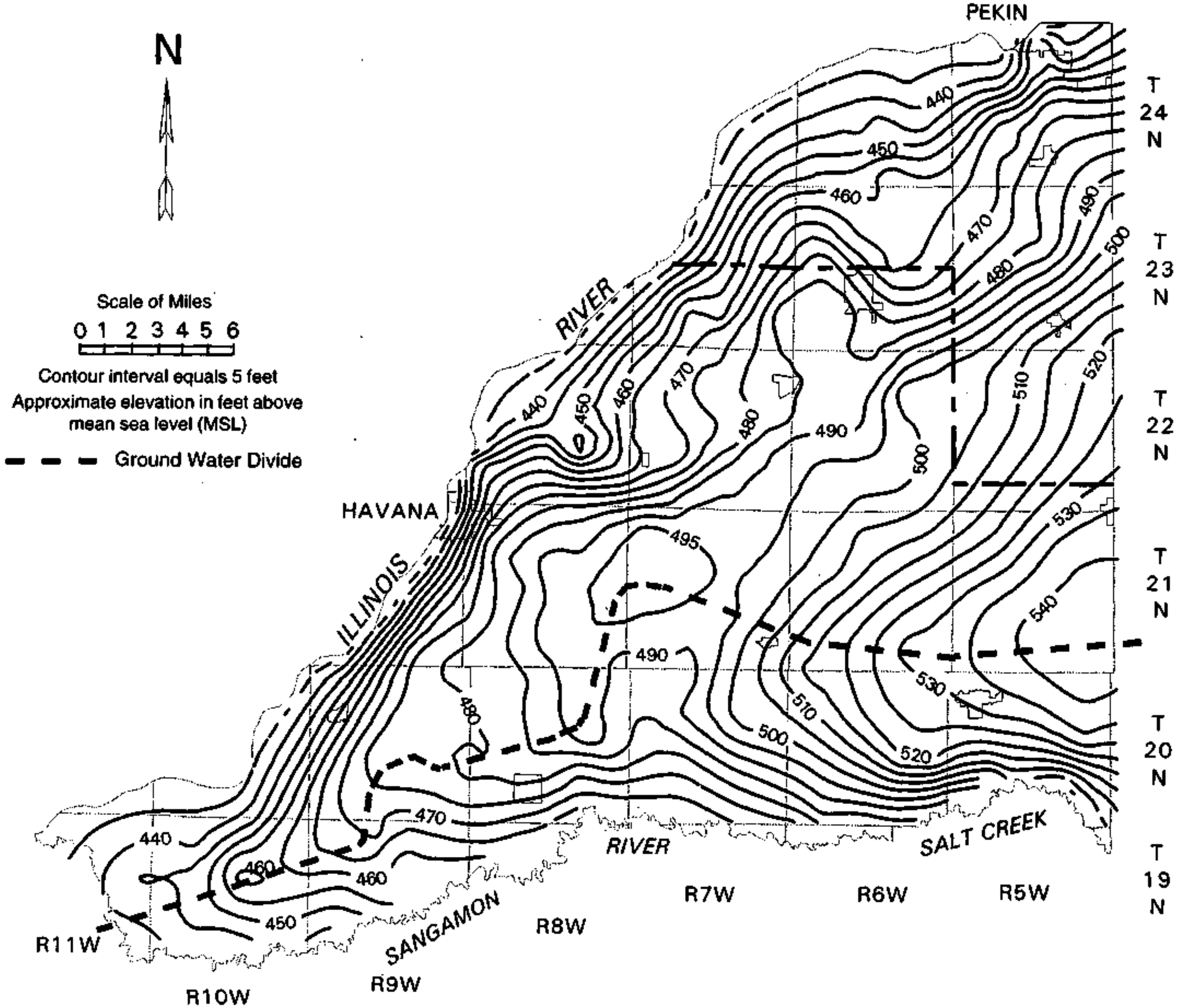

Figure 7. Potentiometric surface of the Havana lowlands sand and gravel aquifer, Spring 1993

North of the ground-water divide, regional ground-water flow is from an elevation of more than 540 msl northeast of Mason City to the west-northwest toward Quiver Creek, the Mackinaw River, and the Illinois River. This indicates that the ground-water gradient averages about 4.2 feet per mile for the span from northeast of Mason City to the Illinois River near Havana.

South of the ground-water divide, regional ground-water flow is from an elevation of more than 540 feet msl northeast of Mason City in a south-southwesterly direction where it discharges to Crane Creek, Salt Creek, or the Sangamon River. The potentiometric surface map indicates a gradient of about 4.9 feet per mile from the area northeast of Mason City south to the Sangamon River. There is a gradient of approximately 2.6 feet per mile in the south ground-water basin from the area northeast of Mason City to the confluence of the Illinois and Sangamon Rivers. The Sangamon River elevation was about 504 feet msl at the intersection of the Sangamon River and the eastern margin of the study area and near an elevation of about 439 feet msl at the confluence of the Illinois and Sangamon Rivers.

Fall 1993 Potentiometric Surface Map

A supplementary mass measurement of wells was added to the original project scope of work to document record-high ground-water levels that were occurring in the Havana lowlands region during the late summer and fall of 1993. These high ground-water levels caused severe flooding in certain areas within Mason and Tazewell Counties and had significant socioeconomic impacts, including ruined crops, disrupted transportation systems, flooded and collapsed home basements, and closed businesses. The areas around the municipalities of Havana and Bath reportedly suffered the greatest impact. The potentiometric surface map for Fall 1993 was developed from 274 water-level measurements taken from September 27 to October 1, 1993. The map shows ground-water levels at or near their record-setting levels within the sand and gravel aquifer system of the Havana lowlands region.

The Fall 1993 potentiometric surface map (figure 8) was developed with the same method used for both the Fall 1992 and Spring 1993 potentiometric maps, as described earlier. The major causes of the high ground-water levels in the region were the record rainfall during the summer and fall and the Illinois River flood stage. The river's water surface elevation during the Fall 1993 mass measurement was approximately 446 feet msl near Pekin, or about 14 and 6 feet higher, respectively, than during the Fall 1992 and Spring 1993 mass measurements. The method used to calculate surface water levels along the Sangamon River for the Fall 1992 and Spring 1993 maps was also used for the Fall 1993 potentiometric map. Sangamon River water-level elevations at the eastern and western margins of the study area were approximately 504 and 445 feet msl, respectively.

The configuration of the potentiometric surface contours for the Fall 1993 map is similar to that for the Fall 1992 and Spring 1993 potentiometric surface maps. The Fall 1993 map also shows the ground-water divide that separates the Havana lowlands

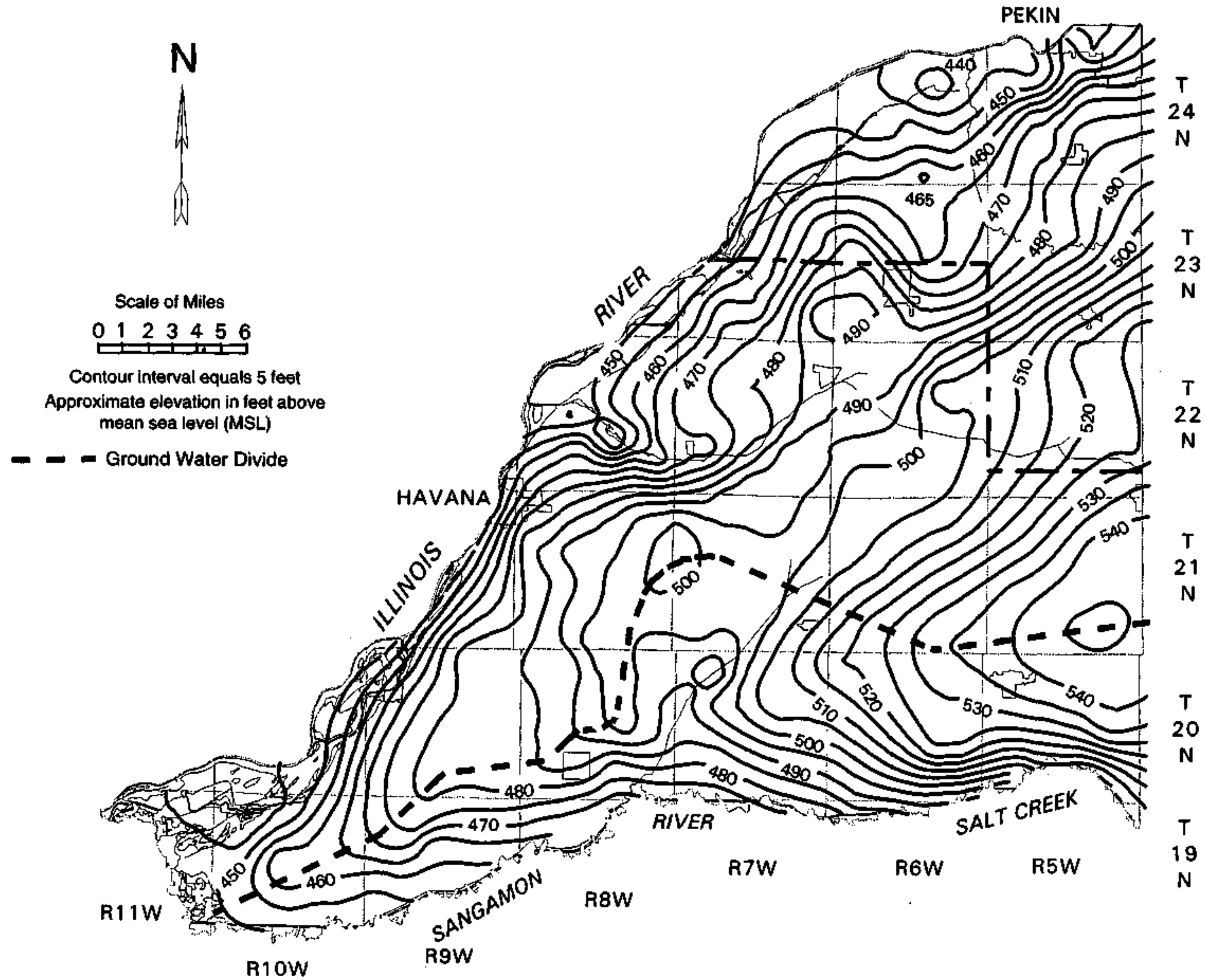

Figure 8. Potentiometric surface of the Havana lowlands sand and gravel aquifer, Fall 1993

region into two basins. From an elevation of more than 545 feet msl in an area northeast of Mason City, ground water moves west-northwesterly toward Quiver Creek, the Mackinaw River, and the Illinois River in the north basin or south-southwesterly toward Crane Creek, Salt Creek, or the Sangamon River in the south basin. The potentiometric map indicates an average ground-water gradient of about 4.0 feet per mile for the span from northeast of Mason City to the Illinois River near Havana. There is a gradient of about 5.1 feet per mile from the area northeast of Mason City south to the Sangamon River. The map indicates a gradient of approximately 2.5 feet per mile in the south ground-water basin from the area northeast of Mason City to the confluence of the Illinois and Sangamon Rivers.

CHANGES IN THE POTENTIOMETRIC SURFACE OF THE AQUIFER

Change maps were constructed using the 1960 potentiometric surface map included in Cooperative Report 3 (figure 25 in Walker et al., 1965), and the potentiometric surface maps for Fall 1992, Spring 1993, and Fall 1993. Comparisons were made between water-level elevations in 1960 and Fall 1992; Fall 1992 and Spring 1993; and Fall 1992 and Fall 1993. The methodology described earlier for development of the potentiometric surface maps was also used for creating Fall 1992 versus Spring 1993 and Fall 1992 versus Fall 1993 change maps.

Methodology for Change Map Development

To facilitate development of the maps that show changes in the ground-water elevations from one time to another, an electronic version of the 1960 potentiometric surface map of ground-water elevations in the Havana lowlands region (figure 25, Walker et al., 1965) was created using Water Survey computer shareware, which determines Lambert coordinates (x and y) of points on a map. A ground-water level elevation (z), determined at the x- and y-coordinates on the map, was assigned to each point digitized. The resulting Lambert coordinates and ground-water elevation data points were then entered into SURFER® computer software, from which a potentiometric surface map of the digitized 1960 map was created. The resulting computer-derived map was very similar, although not identical, to Walker's hand-drawn potentiometric surface map of 1960 ground-water elevations. This computer version of Walker's 1960 map was then used to create the change map, which allows preliminary assessment of the impacts of 30 years of ground-water resource development.

Identical methods were used to develop the 1960 (computer simulated) versus Fall 1992, Fall 1992 versus Spring 1993, and Fall 1992 versus Fall 1993 potentiometric surface change maps. In each of these pairs, the earlier potentiometric surface elevation map was subtracted from the later map using SURFER® computer software. The resulting change maps for 1960 to Fall 1992, Fall 1992 to Spring 1993, and Fall 1992 to Fall 1993 were then overlain on base maps of the Havana lowlands region, developed with AutoCAD® computer software.

Changes in the Potentiometric Surface, 1960 to Fall 1992

A map showing the difference in ground-water elevations from 1960 to Fall 1992 was developed using the computer-derived version of the 1960 map and the Fall 1992 potentiometric surface map described above. The resulting potentiometric surface change map (figure 9) shows that throughout most of the study area, the Fall 1992 ground-water levels are within 5 feet (plus or minus) of the 1960 levels. The change map suggests that ground-water levels may be as much as 10 to 15 feet higher in southeast Mason County near Mason City and in the northeastern part of the area near Pekin. However, examination of the data used to construct the two potentiometric maps suggests that the greater difference in these areas is probably due to the greater number of data points used for the 1992 map, complicated by the human (1960) versus electronic (Fall 1992) interpretation of available data points.

At this time, elevation differences of less than 5 feet are not judged to be significant. The reconnaissance level of vertical control—interpretation of land surface elevation from topographic maps both in 1960 and present—could be a significant portion of the 5 feet. The extensive development for agricultural irrigation since about 1960 has not caused a lowering of ground-water levels or depletion of the ground-water resource.

Changes in the Potentiometric Surface, Fall 1992 to Spring 1993

A map showing the difference between the Fall 1992 and Spring 1993 potentiometric surfaces (figure 10) was created by subtracting the two potentiometric surface maps using SURFER® computer software. The resulting change map indicates that ground-water elevations in the Havana lowlands area increased about 3 feet over the entire region from seasonal low elevations in Fall 1992 to Spring 1993. No areas were found where ground-water levels were lower in the spring than in the fall. A few areas in the region saw rises of as much as 7 feet. Sites that had more than 7 feet of change include an area near Pekin, a site north of Manito, an area south of Easton, and two sites along the Sangamon River in the southwestern portion of the Havana lowlands region. The change map for the Fall 1992 and Spring 1993 potentiometric surfaces indicates that ground-water elevations increased about 5 feet near the Illinois River. An increase of approximately 8 feet in Illinois River surface elevations was observed between the Fall 1992 and Spring 1993 mass measurements.

Changes in the Potentiometric Surface, Fall 1992 to Fall 1993

A change map for the Fall 1992 and the Fall 1993 potentiometric surfaces (figure 11) was generated to document the impacts of record-setting rainfall (ground-water recharge) and Illinois River flood stages on the sand and gravel aquifer of the Havana lowlands region. The change in the potentiometric surfaces was calculated by subtracting the two potentiometric surface maps using SURFER® computer software. The resulting change map indicates that ground-water elevations in the Havana lowlands area increased about 5 to 7 feet over the entire region from the seasonal low ground-water elevations in Fall 1992. A few scattered areas in the Havana lowlands region saw

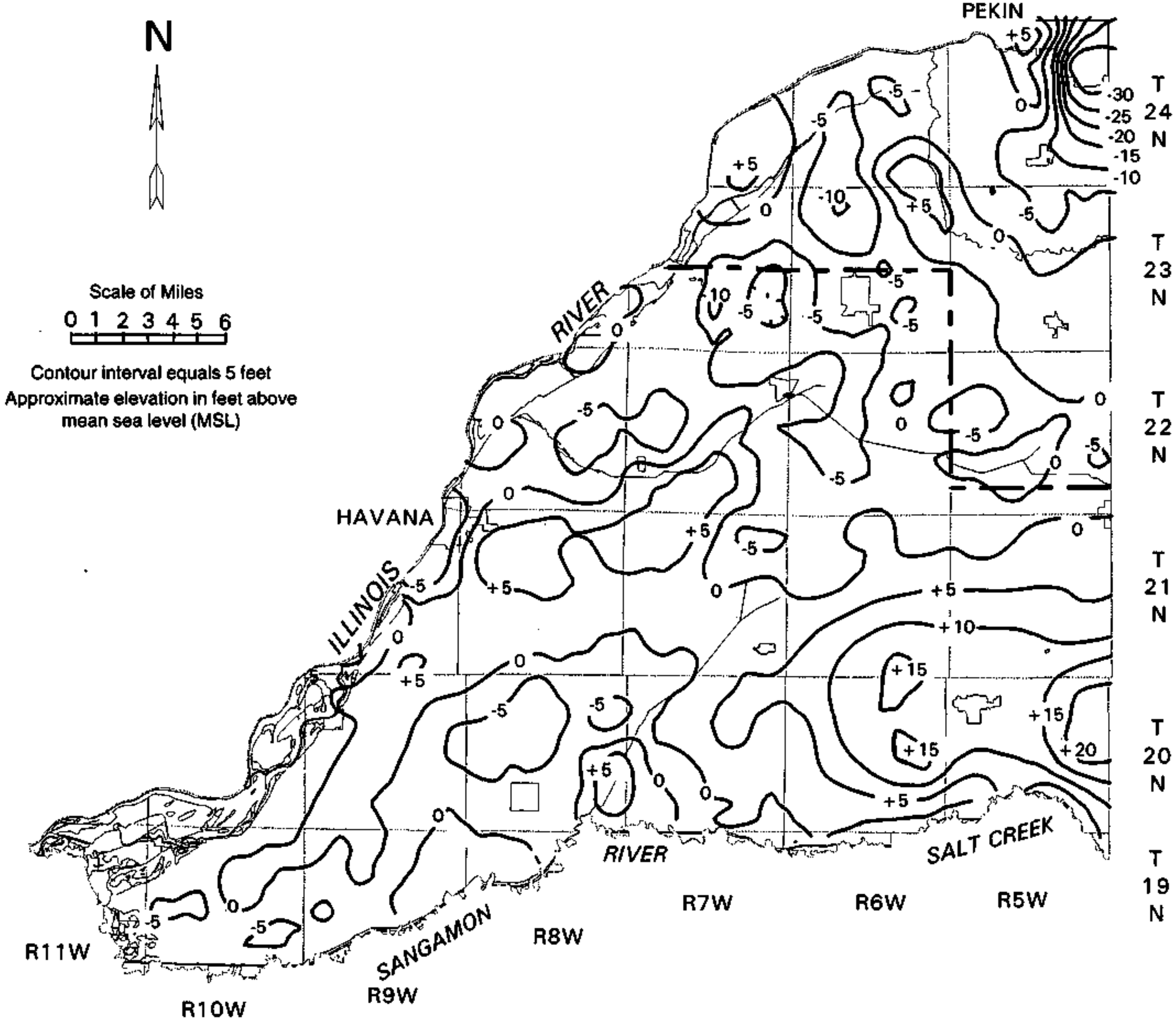

Figure 9. Change in potentiometric surface of the Havana lowlands sand and gravel aquifer, 1960 to Fall 1992

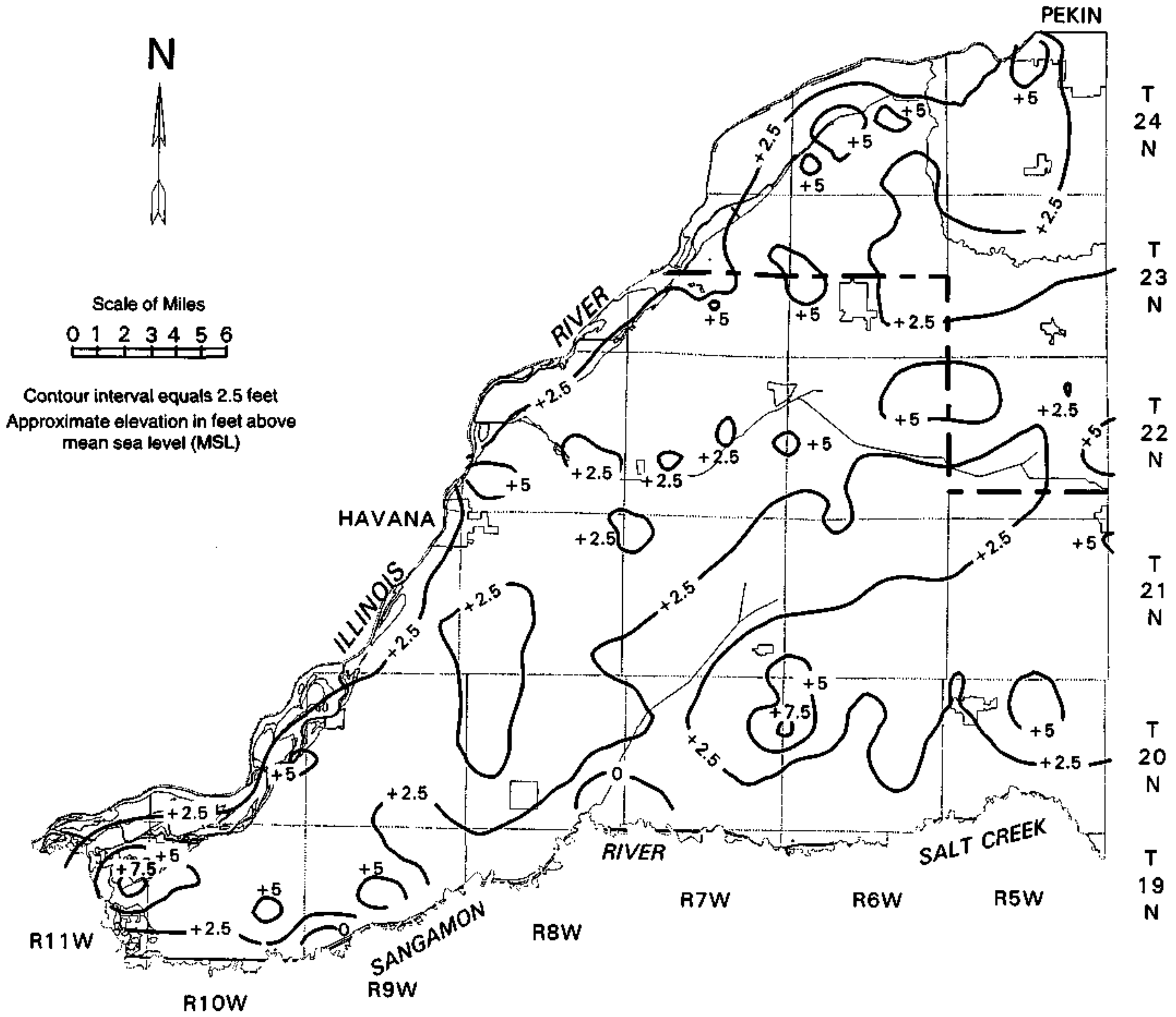

Figure 10. Change in potentiometric surface of the Havana lowlands sand and gravel aquifer, Fall 1992 to Spring 1993

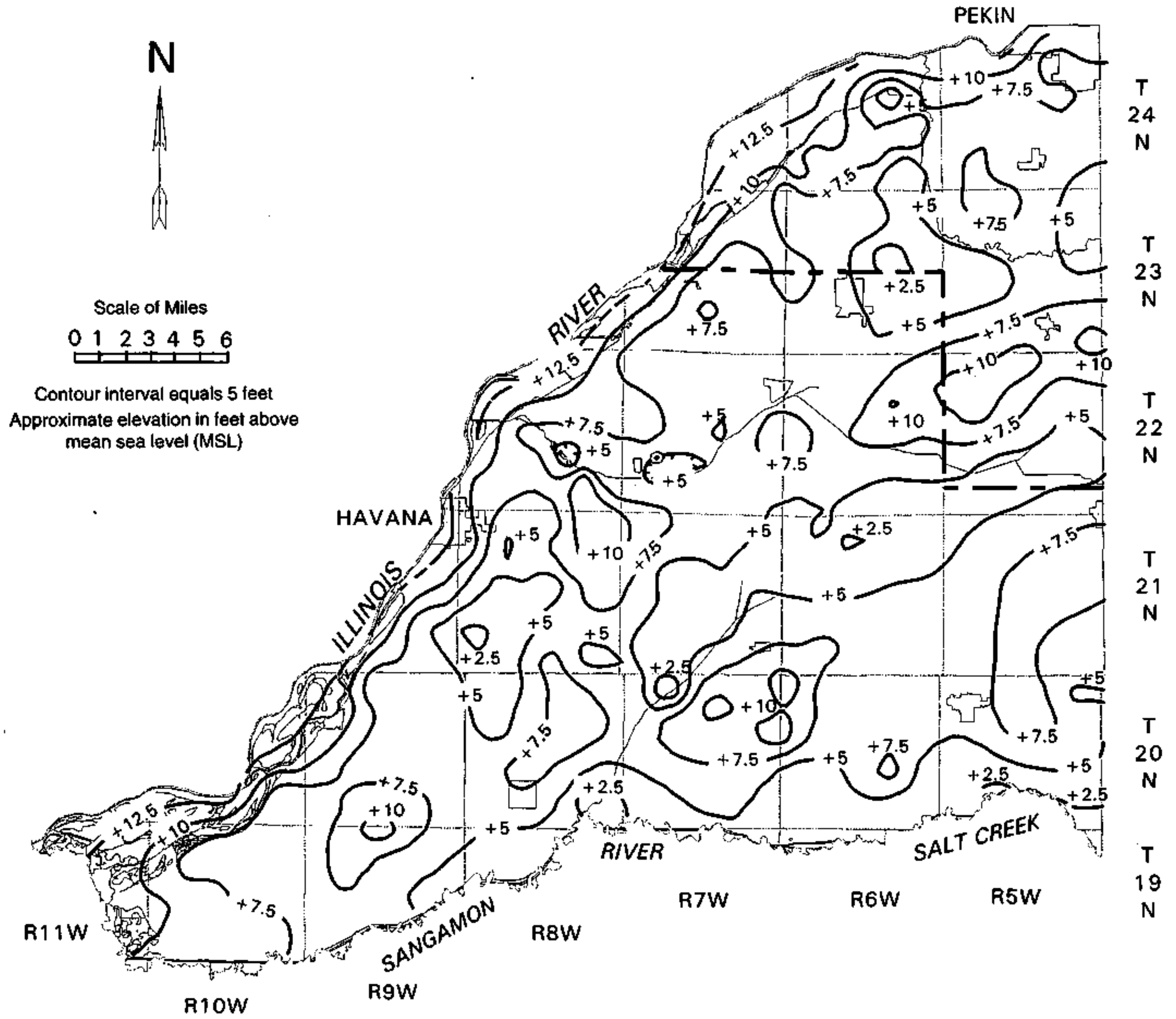

Figure 11. Change in potentiometric surface of the Havana lowlands sand and gravel aquifer, Fall 1992 to Fall 1993

increases of as much as 9 feet. Sites that experienced more than 9 feet of change include an area west-southwest of Pekin, a site south of Green Valley, an area south of Easton, a site east of Havana, and a site west of Kilbourne. The change map for the Fall 1992 and Fall 1993 potentiometric surfaces indicates that ground-water elevations increased about 9 to 13 feet in close proximity to the Illinois River. An increase of approximately 14 feet in Illinois River surface elevations was observed between the Fall 1992 and Fall 1993 mass measurements.

LONG-TERM OBSERVATION WELL NETWORK

A limited long-term observation well network was established to monitor water levels within the sand and gravel aquifer of the Havana lowlands. The increased pumpage from the aquifer since about 1960 and interest in expanded future development of the ground-water resource made apparent the need for a dedicated limited network of observation wells to monitor ground-water levels on a long-term basis. Such a network of observation wells will show seasonal fluctuations and regional long-term trends in ground-water elevations.

Selection of Observation Well Sites

Selection of well sites for the network was based primarily on attaining a reasonable spatial distribution throughout the area. Considerations in choosing specific locations included ease of vehicular access for maintenance and servicing and long-term site availability. Project budget restrictions were also considered in attempting to establish this network of wells. Advantage was taken of observation wells that remained from previous studies and other unused wells. The network comprises 11 observation wells, ten of which are located on publicly owned land.

The long-term observation well network includes five existing wells and six new wells drilled specifically for this network. The existing wells are located near Snicarte, in the Mason County Wildlife Refuge and Public Recreation Area, in Easton, at Sand Ridge State Forest, and at Pekin. Although the well at Snicarte is considered to be part of the Havana lowlands network, it is also part of the statewide network of observation wells operated by the Water Survey. The Snicarte well has significant historical value, as its water levels have been measured since 1958 with a Leupold & Stevens continuous recorder (Type F). The six new wells were drilled near Mason City, San Jose, Green Valley, Mason County State Tree Nursery, Illinois Route 136 Rest Area near Havana, and at the IDOT-DWR facility south of Havana.

Table 4 provides a summary of the name, location, licensee, and depth of the 11 wells that establish the long-term network for the Havana lowlands region. Figure 12 shows the location of the wells in the long-term network, which is to be operated, in part, by the Imperial Valley Water Authority.

Table 4. Summary of Long-Term Observation Wells

Name	*ID*	*Location*	*Depth*	*Licensor/ licensee*	*Remarks*
Snicarte	MTOW-1	Section 11.8b, T.19N., R.10W., Mason County	40.5 feet	Harold Banks	Inactive domestic well
Mason City	MTOW-11	Section 18.2a, T.20N., R.5W., Mason County	63 feet	Mason City/ IVWA	New well
Mason County Wildlife Refuge & Recreation Area	MTOW-3	Section 14.8c, T.20N., R.9W., Mason County	24 feet	IDOC/IVWA (pending)	Installed in 1985 for ISGS study
Easton	MTOW-2	Section 25.8a, T.21N., R.7W., Mason County	82 feet	Village of Easton/IVWA	Existing well
Illinois Route 136 Rest Area	MTOW-7	Section 3.7e, T.21N., R.8W., Mason County	44 feet	IDOT-HWY/ IVWA	New well
IDOT-DWR	MTOW-9	Section 12.8e., T.21N., R.9W., Mason County	48 feet	IDOT-DWR/ ISWS	New well
San Jose	MTOW-10	Section 36.2d, T.22N., R.5W., Mason County	56 feet	Village of San Jose/IVWA	New well
Sand Ridge SR-11	MTOW-4	Section 2.8d, T.22N., R.7W., Mason County	27 feet	IDOC/ISWS (pending)	Installed in 1989 for ISWS/IDOC hatchery study
Mason State Tree Nursery	MTOW-6	Section 33.8f, T.22N., R.7W., Mason County	45.5 feet	IDOC/ IVWA	New well
Green Valley	MTOW-8	Section 34.1c, T.23N., R.5W., Mason County	53.5 feet	IDOT-HWY/ IVWA	New well
Pekin-OW8	MTOW-5	Section 3.6a, T.24N., R.5W., Tazewell County	49 feet	Cityof Pekin/ ISWS	Installed in 1991 for ISWS study

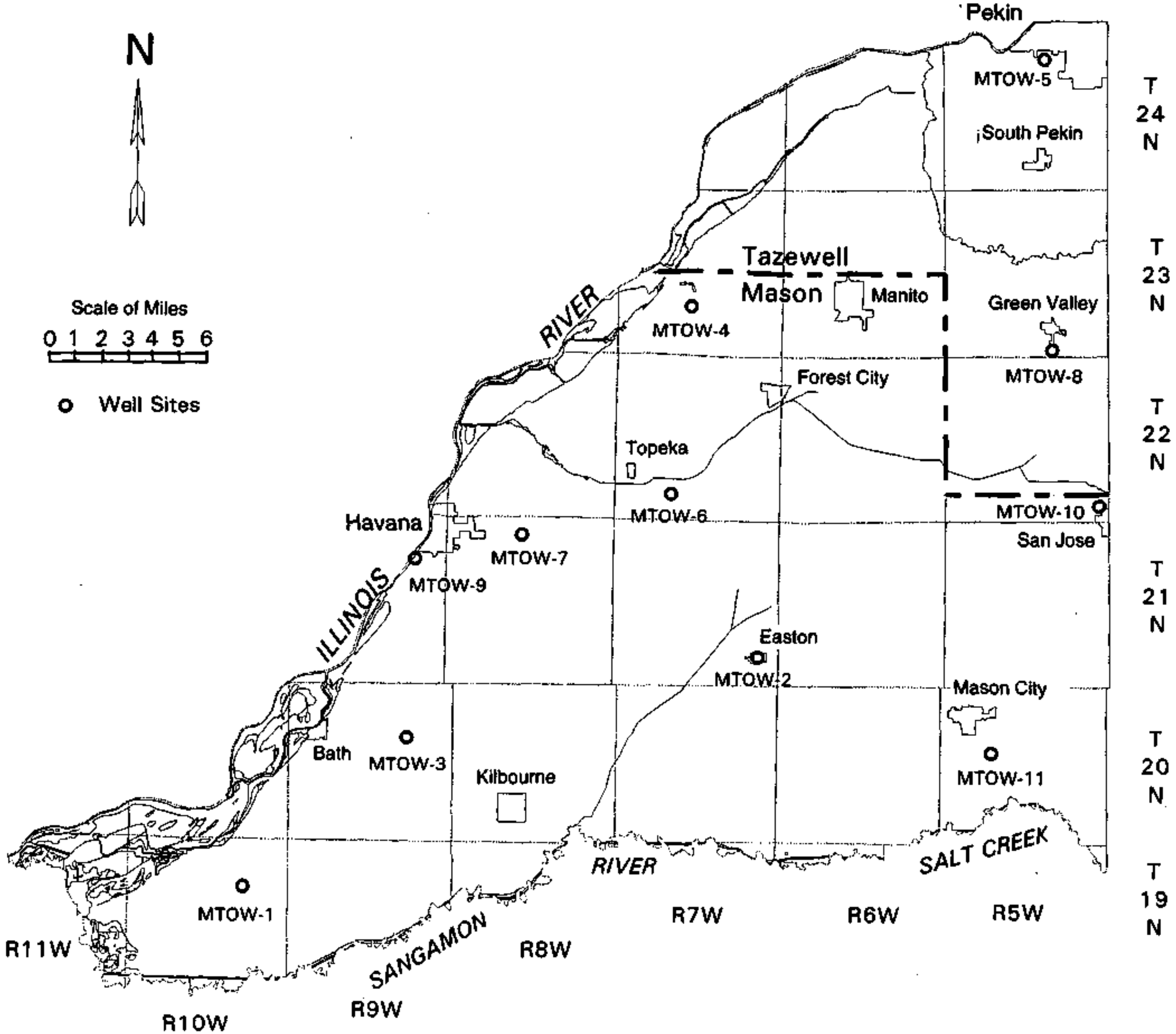

Figure 12. Location of wells included in the long-term network

Drilling of Observation Wells

Obtaining the approval of a license from several public entities for the use of observation well sites caused considerable delay in the construction of the new wells. The first three new observation wells were drilled on July 13 and 15, 1993, at the Mason State Tree Nursery, the Route 136 Rest Area east of Havana, and at the site near Green Valley. Other work commitments and weather conditions prevented additional well drilling until March 1994. The observation well at the IDOT-DWR facility south of Havana was drilled March 15, the well near San Jose on March 23, and the well near Mason City on March 25.

Observation Well Construction Features

All of the new observation wells are built of 2-inch-diameter PVC well casing with a 5-foot length of 2-inch-diameter PVC well screen attached at the bottom. The well screen has 0.010-inch slot openings. The well casing screen assembly extends from about 1 to 4 feet above land surface with the bottom of the well screen at a depth of from about 25 to 65 feet below land surface, depending on the site. The tops of most wells are equipped with a steel well protector about 5 feet long, the top of which is placed at the top of the well casing (see figure 13).

Exceptions to these typical construction features include the observation wells at Snicarte, Easton, and Sand Ridge. The Snicarte well is an inactive, domestic, brick-lined water supply well, about 36 inches in diameter and approximately 40 feet deep. The existing well at Easton was previously used as a standby firefighting well. It is constructed with 4-inch-diameter steel casing and is finished at a depth of about 82 feet below land surface. Well screen information for the Easton well is not available. The observation well in the Sand Ridge State Forest has 2-inch-diameter galvanized steel casing and a 4-foot drive point well screen.

Additional information regarding the construction features of individual observation wells is included in Appendix B.

SUMMARY AND RECOMMENDATIONS

This reconnaissance study has established a network of wells to permit the measurement of ground-water levels in many wells within a short time period, that is, a "mass measurement." The network presently consists of 290 existing wells, with about 7 to 18 wells included within most legal townships in the Havana lowlands region.

Three mass measurements of ground-water levels were conducted during the project period. These data resulted in the development of three maps of the potentiometric surface of the sand and gravel aquifer: for Fall 1992, Spring 1993, and Fall 1993. The Fall 1992 map was compared to the map developed by Walker et al. (1965) for 1960, indicating that ground-water levels in Fall 1992 were generally within 5 feet

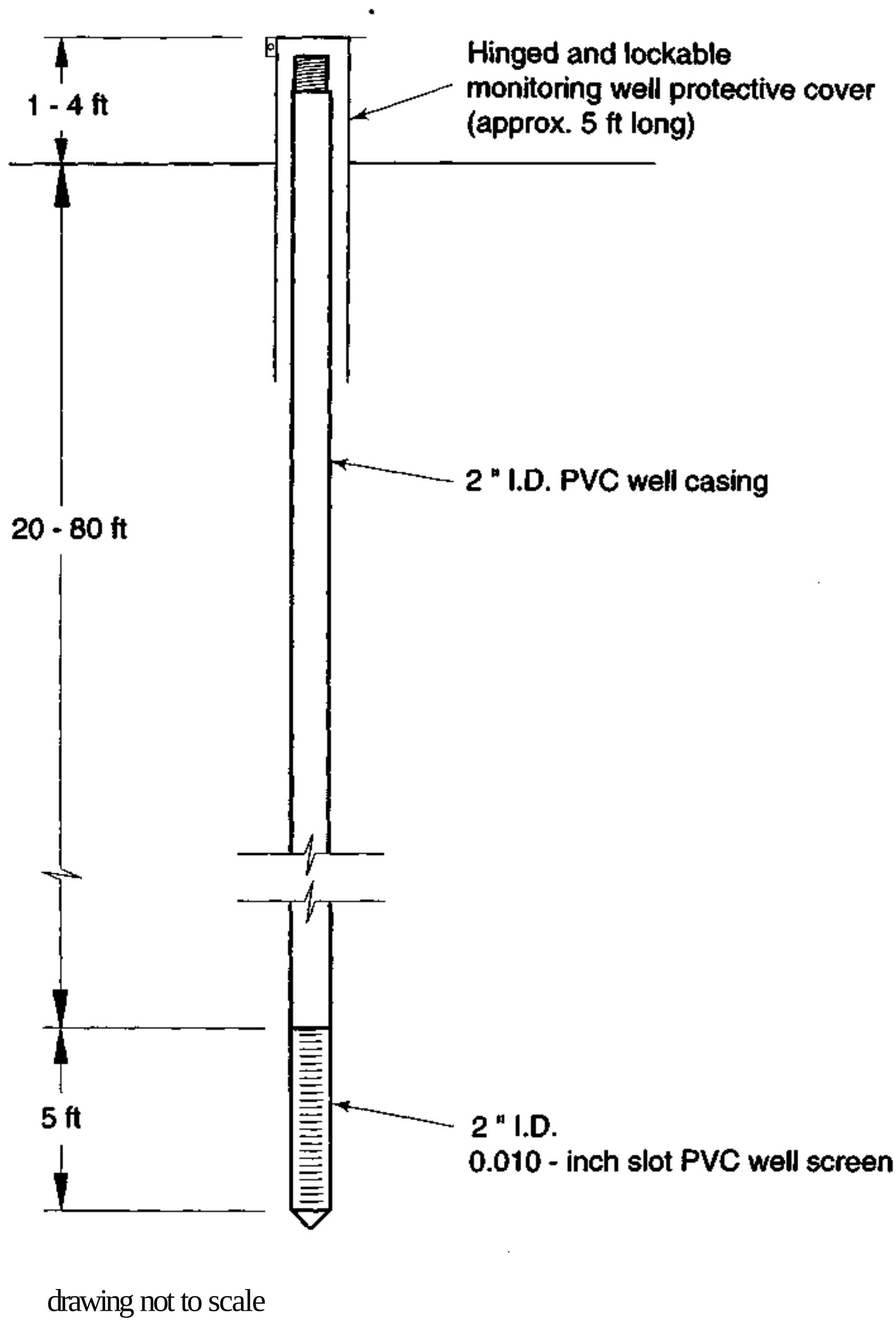

Figure 13. Construction feature schematic of long-term observation well

(plus or minus) of the elevations in 1960. This suggests that the extensive development of the ground-water resource for agricultural irrigation has not diminished the resource. This study contributes to the understanding that the sand and gravel aquifer has the capacity both to absorb impacts of concentrated and nearly continuous irrigation withdrawals during drought periods, such as that experienced in 1988 and 1989, and to recover in future years of average and above average precipitation, as in 1993. This is illustrated by the hydrograph in figure 4 for the Snicarte observation well. Water-level data for this well also suggest that the natural influences on ground-water levels still predominate the annual fluctuations. Annual fluctuations of the ground-water levels in the 1980s and early 1990s are only slightly greater, if at all, than during the 1960s and 1970s when withdrawals for irrigation were much less.

Mass measurements in the well network established for this project can be conducted every 5 to 10 years or following a year in which significant expansion of irrigation has occurred. A mass measurement of ground-water levels may also be considered during or following a significant drought period to monitor and document effects of the drought and the above average withdrawals for irrigation.

A limited network of new and existing dedicated observation wells was established to enable future long-term monitoring of ground-water levels in the region. The network includes 11 wells, seven of which are licensed directly to a project sponsor, the Imperial Valley Water Authority, and four wells for which the Water Survey has either a license, written memorandum of understanding, or a long cooperative relationship with the well owner. Ground-water level data collected from this limited network of observation wells will allow monitoring of the natural fluctuations of ground-water levels and possible regional impacts of irrigation withdrawals. Expansion of the network may be considered at any time fiscal resources allow but will certainly be warranted if and when future data suggest that the impacts of irrigation withdrawals are much greater than thought at present.

Based on estimated irrigation withdrawals of about 106 mgd for 1989 (Bowman and Kimpel, 1991) and estimated natural recharge to the sand and gravel aquifer of about 300 mgd (Walker et al., 1965), it appears that present withdrawals may be about 35 to 40 percent of the natural recharge. However, Visocky and Sievers (1992) reported that some methods of estimating natural recharge resulted in higher recharge rates than were estimated by Walker et al. (1965). The significant expansion of agricultural irrigation expected in this area in the future suggests that further efforts to understand natural recharge and studies to refine the recharge estimates should be considered. There still seems to be validity in the finding of Walker et al. (1965) that ultimately the safe yield of the sand and gravel aquifer depends on natural recharge.

The dedicated network of monitoring wells and periodic mass measurement of ground-water levels offer adequate resource monitoring for the near future. This information, however, must be supplemented with periodic estimates of ground-water withdrawals. Maintaining a central database of all existing and new high-capacity wells and acres irrigated in the region is a requirement for meaningful estimates of withdrawals. Results of this monitoring program will provide adequate warning for a resource management plan to be developed and implemented prior to serious adverse impacts on the aquifer system.

Ultimately, some degree of management of withdrawals from this aquifer may be needed. A relatively detailed computer model of the aquifer will assist greatly in the strategic management decisions that may be required. Besides providing an improved understanding of natural recharge, additional data on the hydraulic characteristics of the aquifer will enhance the model's ability to simulate the natural conditions. Consideration may be given to developing a methodology for using existing high-capacity irrigation wells to collect appropriate water-level and pumping rate data to determine aquifer transmissivity.

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Appendix A.

Water-level data for wells in the Havana lowlands region

Appendix A. Water-Level Data for Wells in the Havana Lowlands Area

Legal location	1992 Owner/operator	Depth (ft)	Use	Estimated land surface elevation (ft above msl)	Measuring Point (MP) height (ft)	*Inventory* Depth to water below MP (ft)	*Inventory* Ground-water elevation (ft above msl)	*Fall 1992* Depth to water below MP (ft)	*Fall 1992* Ground-water elevation (ft above msl)	*Spring 1993* Depth to water below MP (ft)	*Spring 1993* Ground-water elevation (ft above msl)	*Fall 1993* Depth to water below MP (ft)	*Fall 1993* Ground-water elevation (ft above msl)
Mason County													
MSN19N08W-05.4e	Gary Bell	113	I	484	0.4	20.06	464.34	20.29	464.11	18.03	466.37	16.10	468.30
MSN19N08W-062b	Gary Bell	113	I	483	0.7	20.50	463.20	19.89	463.81	17.60	466.10	15.60	468.10
MSN19N09W-03.7f	Al Baker	115	I	490	0.7	22.42	468.28	23.28	467.42	23.28	467.42	12.07	478.63
MSN19N09W-04.2b	Gary Bell	107	I	495	0.5	27.40	468.10	28.03	467.47	24.23	471.27	18.53	476.97
MSN19N09W-05.4e	Jeffrey Clark	113	I	473	1.0	7.98	466.02	9.44	464.56	5.17	468.83		
MSN19N09W-06.4e	Arthur Finch	95	I	472	0.5			8.27	464.23	4.58	467.92	1.70	470.80
MSN19N09W-07.8d	Morris Bell		I	466	0.0			5.59	460.41	1.93	464.07	-0.20	466.20
MSN19N09W-083b	Rocky Adkins	102	I	482	0.7	21.13	461.57	21.63	461.07	18.08	464.62	13.62	469.08
MSN19N09W-10.6g	Gary Bell	123	I	490	0.0	32.16	457.84	32.52	457.48	29.83	460.17	26.15	463.85
MSN19N09W-10.7b	Rocky Adkins		I	493	1.0	36.11	457.89	36.43	457.57	34.27	459.73	31.27	462.73
MSN19N09W-17.1e	Rocky Adkins		I	478	1.1	21.44	457.66	23.25	455.85	19.01	460.09	15.83	463.27
MSN19N09W-17.5e	Rocky Adkins	62	I	485	0.6	32.55	453.05	32.60	453.00	28.99	456.61	25.32	460.28
MSN19N09W-20.8g	Rocky Adkins		I	465	0.0	15.32	449.68	17.62	447.38	13.30	451.70	10.82	454.18
MSN19N09W-22.7g	Rocky Adkins	73	I	456	0.0	7.60	448.40	7.75	448.25	5.88	450.12	1.50	454.50
MSN19N09W-30.3b	Mason County		SW	465	3.0	23.78	444.22	25.22					
MSN19N10W-02.3C	Doug Blessman	82	I	457	1.0	5.85	452.15	6.98	451.02	2.63	455.37	1.30	456.70
MSN19N10W-03.1h	Larry Blessman	76	I	448	1.0	5.04	443.96	10.58	438.42	6.70	442.30	3.34	445.66
MSN19N10W-04.2d	James Sarff	81	I	450	0.3	11.88	438.42	13.21	437.09	9.03	441.27	6.66	443.64
MSN19N10W-08.2e	James Sarff	81	I	445	0.0	8.13	436.87	9.47	435.53	4.73	440.27	2.98	442.02
MSN19N10W-10.7b	DougBlessman	73	I	457	1.0	4.63	453.37	5.99	452.01	1.55	456.45	-1.00	459.00
MSN19N10W-11.8a	ISWS (Snicarte)	40	OW	490	1.5	36.90	454.60	36.99	454.51	33.82	457.68	30.32	461.18
MSN19N10W-15.3g	DougBlessman	73	I	470	0.8	9.45	461.35	10.34	460.46	6.77	464.03	3.75	467.05
MSN19N10W-16.4d	Larry Barnett	88	I	460	0.5			14.82	445.58	10.00	450.50	5.47	455.03
MSN19N10W-18.1g	Jim Sarff		I	450	1.5	10.02	441.48	11.30	440.20	5.82	445.68	3.04	448.46
MSN19N10W-19.2f	Staley Brothers		I	460	0.3	21.88	438.42	23.03	437.27	18.46	441.84		
MSN19N10W-20.2b	Lloyd Stone		I	460	0.0			15.64	444.36	11.57	448.43		
MSN19N10W-22.4d	Paul Sandidge		I	460	0.0								

Appendix A. (Continued)

Legal location	1992 Owner/operator	Depth (ft)	Use	Estimated land surface elevation (ft above msl)	Measuring Point (MP) height (ft)	Inventory: Depth to water below MP (ft)	Inventory: Ground-water elevation (ft above msl)	Fall 1992: Depth to water below MP (ft)	Fall 1992: Ground-water elevation (ft above msl)	Spring 1993: Depth to water below MP (ft)	Spring 1993: Ground-water elevation (ft above msl)	Fall 1993: Depth to water below MP (ft)	Fall 1993: Ground-water elevation (ft above msl)
MSN19N10W-23.2b	Eula Brown		I	464	0.0			18.15	445.85	11.94	452.06	9.76	454.24
MSN19N11W-13.4b	Duane Taylor		I	450	0.0	8.27	441.73	13.20	436.80	3.77	446.23		
MSN20N05W-01.8a	Clinton Fulk		D	565	1.9	27.20	539.70	28.23	538.67	24.78	542.12		
MSN20N05W-05.8d	Dan Harris	90	D	586	1.5	55.54	531.96	55.06	532.44	52.72	534.78	49.03	538.47
MSN20N05W-10.6b	John Whitney		I	575	0.9	46.74	529.16	48.59	527.31	41.35	534.55	38.10	537.80
MSN20N05W-14.1a	Barry Nagle		D	559	0.8	32.02	527.78	30.03	529.77	25.95	533.85	22.96	536.84
MSN20N05W-17.2f	Ainsworth Seed Co.		I	570	0.8	45.10	525.70	44.22	526.58	41.49	529.31	38.60	532.20
MSN20N05W-28.4h	Robert Martin	150	F	561	1.7	53.56	509.14	52.84	509.86	51.19	511.51	49.52	513.18
MSN20N05W-2a5f	Raymond Keith	31	AD	515	1.9	10.60	506.30	10.24	506.66	8.48	508.42	8.20	508.70
MSN20N06W-05.3b	Ken Hoff	125	D	608	2.4	97.09	513.31	96.65	513.75	93.63	516.77	90.23	520.17
MSN20N06W-06.5c	Russell Birch	160	I	538	0.5	28.84	509.66	30.24	508.26	22.72	515.78	18.37	520.13
MSN20N06W-12.5b	Jerry Nelson	135	D	580	1.2	58.83	522.37	58.17	523.03	55.44	525.76	52.19	529.01
MSN20N06W-15.8f	Ray Tracy		D	589	1.3	73.24	517.06	72.35	517.95	70.53	519.77	67.94	522.36
MSN20N06W-18.7e	John Walters	210	D	630	1.1	130.30	500.80	136.89	494.21	127.44	503.66	124.60	506.50
MSN20N06W-23.6b	Bill Swaar	130	D	572	1.5	45.48	528.02	42.98	515.52	51.77	521.73	49.02	524.48
MSN20N06W-24.5c	Albert Hill	140	D	561	0.6	52.15	509.45	42.24	519.36	40.20	521.40	37.89	523.71
MSN20N06W-2a3g	Neil Conklen		D	625	1.4	125.73	500.67	125.18	501.22	124.00	502.40	120.20	506.20
MSN20N06W-30.2h	Lewis Moehring		D	630	1.4	137.50	493.90	137.09	494.31	136.24	495.16	134.80	496.60
MSN20N06W-32.5a	Brent Carter	100	D	505	2.2	23.39	483.81	22.91	484.29	21.35	485.85	20.49	486.71
MSN20N06W-35.3f	R.Lenard Reed	113	F	578	1.6	89.48	490.12	88.07	491.53	86.03	493.57	84.95	494.65
MSN20N07W-04.8a	Mason County		SW	493	3.4	11.70	484.68	11.32	485.06	11.55	484.83	12.19	484.19
MSN20N07W-06.1c	Glen Fanter	108	I	495	0.0			8.36	486.64	6.22	488.78	1.91	493.09
MSN20N07W-07.4a	Steve Krause		I	492	1.0	10.72	482.28	10.50	482.50			4.71	488.29
MSN20N07W-09.6a	Kenneth Smith	112	I	501	0.5	12.67	488.83	12.27	489.23	10.00	491.50	2.65	498.85
MSN20N07W-10.4g	Kenneth Smith	113	I	511	0.2			17.45	493.75	13.40	497.80	6.47	504.73
MSN20N07W-12.2d	Ainsworth Seed Co.		I	538	0.4	37.78	500.62	36.31	502.09	32.22	506.18	27.80	510.60
MSN20N07W-14.6e	Kenneth Smith	150	I	545	2.0	50.22	496.78	49.29	497.71	45.33	501.67	40.50	506.50
MSN20N07W-l8.2b	Nick Hawks	86	I	489	0.5	9.76	479.74	9.37	480.13	7.00	482.50	2.77	486.73

Appendix A. (Continued)

Legal location	1992 Owner/operator	Depth (ft)	Use	Estimated land surface elevation (ft above msl)	Measuring Point (MP) height (ft)	*Inventory* Depth to water below MP (ft)	*Inventory* Ground-water elevation (ft above msl)	*Fall 1992* Depth to water below MP (ft)	*Fall 1992* Ground-water elevation (ft above msl)	*Spring 1993* Depth to water below MP (ft)	*Spring 1993* Ground-water elevation (ft above msl)	*Fall 1993* Depth to water below MP (ft)	*Fall 1993* Ground-water elevation (ft above msl)
MSN20N07W-21.3a	Edward Kirby		D	534	0.2	58.00	476.20	57.26	476.94	56.47	477.73	51.46	482.74
MSN20N07W-35.3d	Tim Pedigo	113	I	481	1.1	7.75	474.35	7.98	474.12	6.15	475.95	3.01	479.09
MSN20N08W-04.3e	Glen Vanderveen		I	493	0.0	10.28	482.72	10.50	482.50	7.23	485.77	4.86	488.14
MSN20N08W-05.7C	Glen Vanderveen		I	487	0.7	4.40	483.30	5.48	482.22	4.63	483.07	2.33	485.37
MSN20N08W-11.6g	Floyd Koke	100	I	501	0.5	13.18	488.32	12.93	488.57	8.54	492.96	3.93	497.57
MSN20N08W-13.4g	Sid VanEtten		I	494	0.0	11.19	482.81	10.90	483.10	7.66	486.34	3.09	490.91
MSN20N08W-17.2d	DonHahn	.	I	490	0.6	8.29	482.31	9.50	481.10	6.97	483.63	4.89	485.71
MSN20N08W-20.3a	RonEbken	112	I	490	0.5	8.46	482.04	8.68	481.82	4.69	485.81	1.13	489.37
MSN20N08W-20.6b	Don Hahn		I	486	0.0	6.30	479.70	7.57	478.43	7.57	478.43	1.52	484.48
MSN20N08W-21.6b	Burke Ebken	108	I	492	0.0	10.52	481.48	11.49	480.51	7.28	484.72	2.57	489.43
MSN20N08W-23.5h	Don Miller		AD	505	0.0	15.12	489.88	15.05	489.95	11.54	493.46	7.03	497.97
MSN20N08W-24.5e	Sid VanEtten	105	I	497	0.9	11.79	486.11	11.95	485.95	9.90	488.00	6.87	491.03
MSN20N08W-26.1b	Sid VanEtten		I	489	0.5	8.48	481.02	13.00	476.50	15.32	474.18	12.91	476.59
MSN20N08W-26.6g	David Kramer	90	AI	498	0.0	24.99	473.01	24.90	473.10	22.00	476.00	19.41	478.59
MSN20N08W-27.7b	Nick Hawks		I	500	0.0	24.58	475.42	24.28	475.72	21.36	478.64	17.91	482.09
MSN20N08W-30.6f	RonEbken	105	I	485	1.0			7.62	478.38	4.42	481.58	1.63	484.37
MSN20N09W-01.4c	DarylFornoff		I	490	1.0			11.52	479.48	8.74	482.26	5.10	485.90
MSN20N09W-04.2b	Dale Heye	92	I	473	0.8			10.70	463.10	8.12	465.68	6.07	467.73
MSN20N09W-09.7c	DarylFornoff		I	467	0.0			7.90	459.10	3.44	463.56	-2.00	469.00
MSN20N09W-10.4g	Veron Heye	117	I	476	0.8	5.95	470.85	6.18	470.62	2.46	474.34		
MSN20N09W-12.6c	Dale Heye	115	I	490	0.0	15.88	474.12	15.32	474.68	12.03	477.97	8.51	481.49
MSN20N09W-13.4h	DarylFornoff	110	I	485	0.8			10.45	475.30	7.65	478.10	4.54	481.21
MSN20N09W-15.7c	VeronHeye	104	I	478	0.9	5.88	473.02	5.66	473.24	1.66	477.24	-0.50	479.40
MSN20N09W-20.3C	Dale Hodgson	%	AI	475	0.0			7.59	467.41	3.41	471.59	0.59	474.41
MSN20N09W-20.7h	Marvin Lascelles	100	I	465	0.0	9.21	455.79	9.39	455.61	4.95	460.05	-0.90	465.90
MSN20N09W-21.3c	Dale Hodgson	117	I	482	0.5			8.89	473.61	4.28	478.22		
MSN20N09W-28.2b	Dean Pfeifer	125	I	483	0.0			11.36	471.64	7.03	475.97	2.47	480.53
MSN20N09W-30.3b	Marvin Lascelles		II	470	0.0	7.58	462.42	8.08	461.92	4.08	465.92	1.20	468.80
MSN20N09W-32.5d	Arthur Finch		I	478	0.0			11.05	466.95	6.90	471.10		

Appendix A. (Continued)

Legal location	1992 Owner/operator	Depth (ft)	Use	Estimated land surface elevation (ft above msl)	Measuring Point (MP) height (ft)	Inventory: Depth to water below MP (ft)	Inventory: Ground-water elevation (ft above msl)	Fall 1992: Depth to water below MP (ft)	Fall 1992: Ground-water elevation (ft above msl)	Spring 1993: Depth to water below MP (ft)	Spring 1993: Ground-water elevation (ft above msl)	Fall 1993: Depth to water below MP (ft)	Fall 1993: Ground-water elevation (ft above msl)
MSN20N09W-34.2g	Don Friend	103		489	0.0								
MSN20N09W-36.3f	Don Friend		I	484	0.5	9.72	474.78	10.11	474.39	7.05	477.45	3.22	481.28
MSN20N10W-24.2b	Everett Keithley		I	455	1.0	12.71	443.29	13.30	442.70	7.43	448.57	2.25	453.75
MSN20N10W-25.6b	Richard Smith	93	I	450	1.0	5.35	445.65	5.72	445.28	1.17	449.83	0.35	450.65
MSN21N05W-0a4f	John Cunningham		I	538	0.7	17.25	521.45	17.84	517.86	18.76	519.94	15.05	523.65
MSN21N05W-11.6b	AlGarlisch	136	I	557	0.5	27.18	530.32	23.42	534.08	19.05	538.45	14.92	542.58
MSN21N05W-12.1h	Hellen Gillmore		D	570	1.0	37.46	533.54	37.89	533.11	32.61	538.39	29.31	541.69
MSN21N05W-16.6f	Randy Phelps		I	589	0.5	68.08	521.42	63.55	525.95	59.55	529.95	56.17	533.33
MSN21N05W-19.1e	Grosch Irrigation	147	D	585	2.0	57.87	529.13	57.18	529.82	54.11	532.89	50.51	536.49
MSN21N05W-24.6f	Delmar Zumwalt		I	557	0.2	21.14	536.06	20.55	536.65	16.06	541.14	12.75	544.45
MSN21N05W-27.8b	Jean Becker		D	590	2.3	55.48	536.82	54.88	537.42	50.69	541.61	47.07	545.23
MSN21N06W-02.1a	David Friend	90	D	512	0.9	4.46	508.44	4.90	508.00	3.94	508.96	2.38	510.52
MSN21N06W-04.6b	Darrell Pfeiffer	125	I	536	0.5			34.75	501.75	32.27	504.23		
MSN21N06W-05.2C	Darrell Pfeiffer	125	I	510	0.5	25.57	484.93	12.86	497.64	10.34	500.16	7.40	503.10
MSN21N06W-05.2f	Darrell Pfeiffer	125	I	510	0.4	13.19	497.21	15.07	495.33	11.74	498.66	9.29	501.11
MSN21N06W-06.4e	Roger Harfst	96	F	502	2.3	7.65	496.60	7.90	496.35	6.62	497.63	3.85	500.40
MSN21N06W-17.2e	Dennis Rauch		D	512	1.3	10.60	502.70	10.88	502.42	9.30	504.00	7.23	506.07
MSN21N06W-23.4g	William Bale	110	D	543	0.0	25.14	517.86	25.03	517.97	21.88	521.12	18.77	524.23
MSN21N06W-25.3a	Dick Robertson	152	D	601	1.1	76.70	525.40	73.48	528.62	70.48	531.62	66.35	535.75
MSN21N06W-29.2b	Steve Krause	100	I	527	0.7			14.07	513.63	10.73	516.97	5.95	521.75
MSN21N06W-30.2b	Walter Behrends	113	I	516	1.0	10.42	506.58	9.23	507.77	5.96	511.04	2.12	514.88
MSN21N06W-35.6f	JeffBirch	174	I	585	1.0	62.75	523.25	58.15	527.85	54.94	531.06	51.35	534.65
MSN21N07W-02.6C	Gary Gathman		I	510	0.0	23.16	486.84	22.87	487.13	20.02	489.98	17.47	492.53
MSN21N07W-04.8a	Darrel Pfeiffer		I	495	0.0	7.32	487.68	6.84	488.16	2.40	492.60	0.72	494.28
MSN21N07W-05.3g	DarylFornoff	116	I	504	0.0	22.79	481.21	22.19	481.81	17.39	486.61	13.47	490.53
MSN21N07W-06.3a	Delbert Hackman	118	I	502	0.8			11.46	491.34	6.24	496.56	1.77	501.03
MSN21N07W-15.1b	Duane Pfeiffer	111	F	502	0.0	9.64	492.36	8.82	493.18	7.28	494.72	3.82	498.18
MSN21N07W-17.2f	James Williams		I	501	1.2	7.35	494.85	7.09	495.11	2.98	499.22		

Appendix A. (Continued)

Legal location	1992 Owner/operator	Depth (ft)	Use	Estimated land surface elevation (ft above msl)	Measuring Point (MP) height (ft)	Inventory: Depth to water below MP (ft)	Inventory: Ground-water elevation (ft above msl)	Fall 1992: Depth to water below MP (ft)	Fall 1992: Ground-water elevation (ft above msl)	Spring 1993: Depth to water below MP (ft)	Spring 1993: Ground-water elevation (ft above msl)	Fall 1993: Depth to water below MP (ft)	Fall 1993: Ground-water elevation (ft above msl)
MSN21N07W-21.7h	Don Hahn		I	499	0.3	5.01	494.29	5.44	493.86	2.86	496.44	0.91	498.39
MSN21N07W-25.2f	Walter Behrends	120	I	511	0.2	11.10	500.10	10.75	500.45	8.12	503.08	4.43	506.77
MSN21N07W-27.1g	Joe Umback	25	AF	500	1.6	8.65	492.95	9.00	492.60	7.92	493.68	5.27	496.33
MSN21N07W-30.3g	Ken Ringhouse	105	I	498	0.0	5.72	492.28	6.06	491.94	3.43	494.57	1.17	496.83
MSN21N07W-324g	Albert Krause	103	I	497	0.7	5.85	491.85	6.13	491.57	5.04	492.66	1.40	496.30
MSN21N07W-33.4d	KenRinghouse		I	497	0.5	9.65	487.85	9.25	488.25	8.13	489.37	4.65	492.85
MSN21N07W-35.5f	Tom Lowers	112	I	507	0.8	9.39	498.41	9.60	498.20	6.49	501.31	2.79	505.01
MSN21N08W-01.2g	Nelson Esselman	96	I	491	0.8			13.29	478.46	7.76	483.99	1.56	490.19
MSN21N08W-01.6c	Gary Gathman	112	I	4%	0.5	12.72	483.78	12.13	484.37	7.75	488.75	1.11	495.39
MSN21N08W-024g	Delbert Hackman		I	491	0.3	14.71	476.59			10.17	481.13	3.95	487.35
MSN21N08W-03.3g	Delbert Hackman		I	486	0.3	9.06	477.24	8.82	477.48	4.88	481.42		
MSN21N08W-05.7g	John Roat		I	472	1.0	8.14	464.86	8.48	464.52	4.20	468.80	0.50	472.50
MSN21N08W-07.3f	Daryl Fornoff		I	479	0.0	10.30	468.70	10.20	468.80	5.19	473.81	-0.62	479.62
MSN21N08W-08.3g	Dan Roat		I	485	0.5	8.64	476.86	8.97	476.53	5.06	480.44		
MSN21N08W-09.4a	Dan Roat		I	495	0.0	9.54	485.46	9.91	485.09	5.98	489.02	3.00	492.00
MSN21N08W-11.6e	Us Golden		I	516	1.0	31.95	485.05	31.59	485.41	27.07	489.93	22.70	494.30
MSN21N08W-11.7d	Us Golden		I	494	0.2	11.32	482.88	10.84	483.36	6.23	487.97	1.13	493.07
MSN21N08W-15.4b	Dan Roat	105	I	500	0.0	8.49	491.51	8.70	491.30	5.11	494.89		
MSN21N08W-17.7g	Wayne Vanderveen	94	I	485	0.0	4.88	480.12	5.77	479.33	2.03	482.97	0.19	484.81
MSN21N08W-21.6f	Don Hahn	99	I	487	0.0	4.71	482.29	4.94	482.06	2.98	484.02	1.06	485.94
MSN21N08W-23.8d	Don Hahn	91	I	501	0.0			12.61	488.39	8.36	492.64		
MSN21N08W-23.8g	Don Hahn	115	I	497	0.5	6.89	490.61	6.99	490.51	2.74	494.76		
MSN21N08W-24.2g	KenRinghouse	95	I	504	0.0	11.58	492.42	11.39	492.61	6.49	497.51	3.03	500.97
MSN21N08W-25.2g	Don Hahn		I	500	1.0			8.61	492.39	4.82	496.18	2.06	498.94
MSN21N08W-27.5f	Marvin Lascelles	135	I	495	0.0			6.90	488.10	3.02	491.98	0.69	494.31
MSN21N08W-28.3f	Glen Vanderveen	105	I	492	0.0	3.98	488.02	4.55	487.45	2.56	489.44	0.88	491.12
MSN21N08W-30.5e	Mason County		SW	483	0.0	7.14	475.86	7.32	475.68	6.90	476.10	5.64	477.36
MSN21N08W-31.1f	Frank Hofreiter		I	485	0.7	4.09	481.61	5.07	480.63	3.53	482.17		
MSN21N08W-33.7g	Paul McClure	126	I	492	0.0	5.59	486.41	6.32	485.68	4.00	488.00	1.96	490.04

Appendix A. (Continued)

Legal location	1992 Owner/operator	Depth (ft)	Use	Estimated land surface elevation (ft above msl)	Measuring Point (MP) height (ft)	*Inventory* Depth to water below MP (ft)	*Inventory* Ground-water elevation (ft above msl)	*Fall 1992* Depth to water below MP (ft)	*Fall 1992* Ground-water elevation (ft above msl)	*Spring 1993* Depth to water below MP (ft)	*Spring 1993* Ground-water elevation (ft above msl)	*Fall 1993* Depth to water below MP (ft)	*Fall 1993* Ground-water elevation (ft above msl)
MSN21N08W-34.4b	Tim Fanter	107	I	498	1.0	9.03	489.97	8.79	490.21	4.61	494.39	-0.50	499.50
MSN21N08W-35.2g	Randy Phelps		I	495	0.8	3.53	492.27	3.60	492.20	1.10	494.70	-0.50	496.30
MSN21N08W-36.3C	Randy Phelps	100	I	493	0.8	6.22	487.58	6.80	487.00	5.10	488.70	2.16	491.64
MSN21N09W-24.3h	DarylFornoff	93	I	480	0.0	13.02	466.98	17.86	462.14	13.27	466.73	9.30	470.70
MSN21N09W-26.2g	Wayne Vanderveen	94	I	469	0.5			6.09	463.41	3.48	466.02	0.65	468.85
MSN21N09W-35.2b	Harold Hahn		I	483	1.0			10.68	473.32	6.49	477.51	2.59	481.41
MSN21N09W-35.6c	Harold Hahn	106	I	478	0.5	6.17	472.33	6.39	472.11	2.50	476.00	-0.77	479.27
MSN22N05W-36.2g	Delmar Durdle	168	I	550	0.3	23.77	526.53	22.59	527.71	19.89	530.41	16.94	533.36
MSN22N06W-02.6g	Dale Meeker	107	I	513	1.0	28.12	485.88	28.38	485.62	24.10	489.90	21.52	492.48
MSN22N06W-037b	Bob Garlisch	117	I	491	0.0	8.02	482.98	8.54	482.46	5.19	485.81	3.26	487.74
MSN22N06W-05.4d	Russel Meyer	103	I	502	0.0	19.35	482.65	19.57	482.43	16.43	485.57	14.32	487.68
MSN22N06W-06.3b	Bruce Clark	104	I	488	1.0			7.52	481.48	3.72	485.28	2.07	486.93
MSN22N06W-09.6b	Fred Friedrich	118	I	492	1.0	9.15	483.85	9.32	483.68	6.90	486.10	4.49	488.51
MSN22N06W-11.7b	John Whitaker	107	I	509	1.0	10.88	499.12	12.45	497.55	5.92	504.08	2.15	507.85
MSN22N06W-13.4C	George Bilyen	125	I	520	0.8	24.18	496.62	24.44	496.36	19.75	501.05	16.63	504.17
MSN22N06W-15.4f	George Bilyen		I	503	0.0	10.25	492.75	11.05	491.95	5.90	497.10	2.00	501.00
MSN22N06W-18.2b	Norman White	81	I	495	1.2			13.83	482.37	9.27	486.93	5.42	490.78
MSN22N06W-18.6g	Bruce Clark		I	503	1.0			22.17	481.83	18.24	485.76	14.50	489.50
MSN22N06W-19.2C	Bob Knoll	106	I	497	0.0	9.81	487.19	10.03	486.97	4.70	492.30	1.85	495.15
MSN22N06W-20.7g	Norman White		I	495	0.0	8.16	486.84	8.99	486.01	5.75	489.25	1.65	493.35
MSN22N06W-21.3h	Fred Friedrich	115	I	499	0.8	12.35	487.45	12.63	487.17	9.77	490.03	4.91	494.89
MSN22N06W-26.8d	Fred Friedrich	113	I	504	0.5	8.09	496.41	8.34	496.16	7.12	497.38	3.53	500.97
MSN22N06W-32.6g	Rick VanOrman	123	I	505	1.0			8.61	497.39	6.01	499.99	3.37	502.63
MSN22N06W-32.8c	Darrell Pfeiffer	125	I	503	0.2	5.46	497.74	5.15	498.05	3.74	499.46	1.48	501.72
MSN22N06W-35.4c	WilbertRauch	107	I	509	0.0			8.35	500.65	6.86	502.14	4.69	504.31
MSN22N07W-02.5h	IDOCSR14	36	OW	498.57	0.0			23.63	474.94	19.80	478.77	17.51	481.06
MSN22N07W-02.8d	IDOCSR11	27	OW	489.55	0.0	15.10	474.45	15.24	474.31	11.54	478.01	9.62	479.93
MSN22N07W-03.1h	IDOCSR13	43	OW	502.48	0.0			29.38	473.10	25.84	476.64	23.69	478.79

Appendix A. (Continued)

Legal location	1992 Owner/operator	Depth (ft)	Use	Estimated land surface elevation (ft above msl)	Measuring Point (MP) height (ft)	Inventory		Fall 1992		Spring 1993		Fall 1993	
						Depth to water below MP (ft)	Ground-water elevation (ft above msl)	Depth to water below MP (ft)	Ground-water elevation (ftabove msl)	Depth to water below MP (ft)	Ground-water elevation (ft above msl)	Depth to water below MP (ft)	Ground-water elevation (ft above msl)
MSN22N07W-06.7f	Roger Messman		I	481	0.7	30.30	451.40	30.38	451.32	26.19	455.51	23.67	458.03
MSN22N07W-07.3e	Keith Freidrich	95	I	483	0.0	20.61	462.39	20.93	462.07	17.66	465.34	13.20	469.80
MSN22N07W-0a2c	Carl Armbrust	102	I	490	1.1	23.45	467.65	23.61	467.49	19.72	471.38	16.32	474.78
MSN22N07W-09.3d	Ron Vance	113	I	510	0.0	36.70	473.30	36.10	473.90	32.67	477.33	29.71	480.29
MSN22N07W-11.2b	Bruce Clark	67	I	493	0.0			15.14	477.86	11.73	481.27	9.89	483.11
MSN22N07W-13.3C	Norman White	122	I	493	1.0	14.53	479.47	15.26	478.74	10.63	483.37	6.66	487.34
MSN22N07W-15.1b	Bruce Clark	103	I	483	0.8			8.98	474.77	6.80	476.95	4.30	479.45
MSN22N07W-16.6b	Ron Vance	105	I	495	. 0.6	27.15	468.45	27.04	468.56	22.88	472.72	19.97	475.63
MSN22N07W-17.5c	Ray Messman	98	I	492	0.5	25.59	466.91	26.77	465.73	22.76	469.74	19.09	473.41
MSN22N07W-l8.4f	Ken Ringhouse	101	I	489	0.0			25.43	463.57	21.18	467.82	17.64	471.36
MSN22N07W-20.7g	Ron Vance	112	I	492	1.5	27.95	465.55	29.35	464.15	24.78	468.72	20.83	472.67
MSN22N07W-22.1d	Ron Meyer		I	487	1.1	11.98	476.12	13.25	474.85	10.97	477.13	7.97	480.13
MSN22N07W-23.3a	Bruce Clark	106	I	493	0.8			9.97	483.78	5.56	488.19	2.77	490.98
MSN22N07W-24.2b	Douglas Whiteker	97	I	497	0.0	10.00	487.00	11.20	485.80	5.78	491.22	2.93	494.07
MSN22N07W-25.2b	Clarence Leinweber		I	505	1.6	20.92	485.68	20.87	485.73	17.26	489.34	14.52	492.08
MSN22N07W-25.8g	Bruce Clark		I	493	0.0			6.81	486.19	3.09	489.91	1.40	491.60
MSN22N07W-26.7d	Bob Knoll	104	I	492	1.0			8.36	484.64	4.69	488.31	1.93	491.07
MSN22N07W-27.4b	Clarence Leinweber	105	I	496	0.0							9.54	486.46
MSN22N07W-29.2g	Stanley Noll	101	I	475	0.0	11.20	463.80	11.47	463.53	9.67	465.33	8.36	466.64
MSN22N07W-32.4b	Forest VanOrman		I	504	0.0			7.88	496.12	5.47	498.53	2.79	501.21
MSN22N07W-33.7a	Bruce Clark		I	493	0.0	8.75	484.25	8.19	484.81	3.59	489.41	0.94	492.06
MSN22N07W-34.7g	DarylFornoff	82	I	492	0.0	7.86	484.14	7.86	483.95	3.73	488.27	0.20	491.80
MSN22N08W-01.3b	Roger Messman	82	I	475	0.0	21.81	453.19	22.24	452.76	17.82	457.18	14.18	460.82
MSN22N08W-14.6C	William Atwater	108	I	479	0.4			28.93	450.47	24.82	454.58	20.93	458.47
MSN22N08W-21.3C	DarylFornoff	76	I	461	0.0	12.78	448.22	14.21	446.79	9.23	451.77	5.87	455.13
MSN22N08W-21.3g	Bruce Clark	84	I	457	0.5	18.40	439.10	19.02	438.48	15.06	442.44	12.87	444.63
MSN22N08W-21.8a	Bruce Clark	109		490									
MSN22N08W-23.8a	Mason County		SW	445	0.0	5.81	439.19	5.99	439.01	5.30	439.70	3.86	441.14
MSN22N08W-24.2b	Ken Ringhouse	102	I	483	0.5	22.21	461.29	22.25	461.25	19.34	464.16	15.32	468.18

Appendix A. (Continued)

Legal location	1992 Owner/operator	Depth (ft)	Use	Estimated land surface elevation (ft above msl)	Measuring Point (MP) height (ft)	*Inventory* Depth to water below MP (ft)	*Inventory* Ground-water elevation (ft above msl)	*Fall 1992* Depth to water below MP (ft)	*Fall 1992* Ground-water elevation (ft above msl)	*Spring 1993* Depth to water below MP (ft)	*Spring 1993* Ground-water elevation (ft above msl)	*Fall 1993* Depth to water below MP (ft)	*Fall 1993* Ground-water elevation (ft above msl)
MSN22N08W-24.6c	Bruce Clark	103	I	480	0.4			29.12	451.28	25.82	454.58	22.50	457.90
MSN22N08W-25.2b	Nelson Esselman	%	I	482	0.0			22.56	459.44	20.00	462.00	18.13	463.87
MSN22N08W-25.6g	Bruce Clark	95	I	471	0.0			15.68	455.32	13.76	457.24	11.88	459.12
MSN22N08W-26.2b	Bruce Clark	100	I	474	0.8							5.00	469.75
MSN22N08W-27.7g	DarylFornoff	88	I	466	0.0	12.43	453.57	13.82	452.18	9.22	456.78	5.73	460.27
MSN22N08W-28.2g	Don Hahn	88	I	467	0.0	12.09	454.91	12.26	454.74	7.90	459.10	3.30	463.70
MSN22N08W-30.5b	Bruce Clark	80	I	467	0.0	18.96	448.04	19.11	446.89	12.56	454.44	10.11	456.89
MSN22N08W-31.2b	Wayne Vanderveen	81	I	465	0.8	9.18	456.62	10.18	455.62	5.37	460.43	0.87	464.93
MSN23N06W-19.3f	Scott Tolbott	119	I	520	0.6			46.27	474.33			38.39	482.21
MSN23N06W-21.7g	Scott Tolbott		I	510	0.0	35.40	474.60	36.43	473.57	32.97	477.03	29.%	480.04
MSN23N06W-22.2g	Bruce Meyer	70	I	468	0.5	5.46	463.04	6.54	461.%	4.18	464.32	3.52	464.98
MSN23N06W-23.3C	Scott Tolbott		I	473	0.5	5.14	468.36	5.79	467.71	5.20	468.30	3.30	470.20
MSN23N06W-24.3a	Ron Meyer		I	476	1.5	6.26	471.24	6.94	470.56	6.05	471.45	4.25	473.25
MSN23N06W-25.3g	Dale Meeker		I	495	0.5	20.75	474.75	21.10	474.40	19.81	475.69	17.56	477.94
MSN23N06W-29.2b	Scott Tolbott	114	I	510	1.0	24.95	486.05	25.44	485.56	21.49	489.51	18.68	492.32
MSN23N06W-32.3e	Scott Tolbott		I	505	1.0	24.58	481.42	24.94	481.06	20.93	485.07	18.24	487.76
MSN23N06W-33.2g	Bruce Meyer		I	493	0.3	12.85	480.45	12.93	480.30	8.99	484.31	6.21	487.09
MSN23N06W-34.5g	Dale Meeker	107	I	490	0.8	12.75	478.05	12.92	477.88	10.45	480.35	8.07	482.73
MSN23N07W-21.2a	IDOC OW5	130	OW	518.17	0.0	61.82	456.35	61.90	456.27	60.89	457.28	56.94	461.23
MSN23N07W-2Zlb	IDOC SR23	68	OW	501.02	0.0	39.%	461.06	40.18	460.84	37.74	463.28	35.07	465.95
MSN23N07W-24.3g	Ronald Armbrust	109	I	510	0.0	36.37	473.63	36.75	473.25	32.88	477.12	29.13	480.87
MSN23N07W-26.8d	IDOC SR20	62	OW	505.89	0.0			50.58	465.31	37.54	468.35	34.87	471.02
MSN23N07W-27.3c	1DOC SE Hatchery	80	OW	513.31	0.0	48.63	464.68	50.65	462.66	47.73	465.58	44.17	469.14
MSN23N07W-27.4h	IDOC North	40	OW	501.13	0.0			42.%	458.17	41.17	459.%	36.61	464.52
MSN23N07W-27.6f	IDOC OW7	109	OW	497.39	0.0			43.31	454.08				
MSN23N07W-27.8g	IDOC SR22	92	OW	512.88	0.0			56.13	456.75	54.13	458.75	50.38	462.50
MSN23N07W-28.8e	Roger Messman	91	I	496	0.5	41.05	455.45	41.76	454.74	36.88	459.62	34.08	462.42
MSN23N07W-32.1d	Roger Messman		I	510	0.0	46.81	463.19	47.10	462.90	43.82	466.18	41.13	468.87

Appendix A. (Continued)

Legal location	1992 Owner/operator	Depth (ft)	Use	Estimated land surface elevation (ft above msl)	Measuring Point (MP) height (ft)	Inventory Depth to water below MP (ft)	Inventory Ground-water elevation (ft above msl)	Fall 1992 Depth to water below MP (ft)	Fall 1992 Ground-water elevation (ftabove msl)	Spring 1993 Depth to water below MP (ft)	Spring 1993 Ground-water elevation (ft above msl)	Fall 1993 Depth to water below MP (ft)	Fall 1993 Ground-water elevation (ft above msl)
MSN23N07W-32.6d	Roger Messman		I	490	0.5	35.80	454.70	35.98	454.52	32.65	457.85	29.86	460.64
MSN23N07W-33.2a	IDOC SR21	47	OW	506.67	0.0	37.95	468.72	38.07	468.60	34.76	471.91	32.91	473.76
MSN23N07W-33.7h	Roger Messman		I	499	0.0	36.41	462.59	36.50	462.50	32.87	466.13	30.32	468.68
MSN23N07W-34.4a	IDOC SR12	40	OW	496.77	0.0			25.47	471.30	22.12	474.65	20.05	476.72
MSN23N07W-34.4e	IDOC SR3	40	OW	501.51	0.0			32.79	468.72	29.55	471.96	27.61	473.90
MSN23N07W-34.5h	IDOC SR17	62	OW	499.95	0.0			40.76	459.19	37.60	462.35	34.93	465.02
MSN23N07W-35.5e	IDOC SR16	42	OW	501.89	0.0			28.10	473.79	24.42	477.47	21.94	479.95
MSN23N07W-35.5h	IDOC SR19	67	OW	517.66	0.0	45.24	472.42	45.59	472.07	41.92	475.74	39.58	478.08
MSN23N07W-35.8e	IDOC SR15	47	OW	506.74	0.0			35.25	471.49	31.76	474.98	29.70	477.04
MSN23N07W-35.8h	IDOC SR18	57	OW	506.46	0.0			37.95	468.51	34.57	471.89	32.51	473.95
MSN23N07W-36.6h	Russel Meyer		I	515	2.0	29.94	487.06	30.06	486.94	26.47	490.53	22.85	494.15
Tazewell County													
TAZ22N05W-03.6f	Earl Urish	128	I	534	0.8	26.28	508.52	26.14	508.66	22.10	512.70	14.80	520.00
TAZ22N05W-06.6a	David VanOrman	128	I	513	0.3	17.20	496.10	16.24	497.06	10.70	502.60	6.02	507.28
TAZ22N05W-11.3d	Lee Haycock	180	D	525	1.4	9.20	517.20	9.43	516.97	7.30	519.10	4.10	522.30
TAZ22N05W-17.5g	Dale Schleders		I	521	0.5	22.77	498.73	22.60	498.90	16.54	504.%	11.44	510.06
TAZ22N05W-22.7f	Clarence Mayrose	125	I	524	0.7	11.93	512.77	12.14	512.56	10.18	514.52	6.74	517.96
TAZ22N05W-25.2h	Robert Betzelberger	180	I	546	0.9	27.15	519.75	26.40	520.50			22.51	524.39
TAZ22N05W-28.6f	Steve Schachtrup	150	I	516	0.7	4.33	512.37	4.69	512.01	3.51	513.19	1.21	515.49
TAZ23N05W-01.1b	Dale Schleders		D	597	1.1	113.29	484.81	103.85	494.25	102.38	495.72	101.15	496.95
TAZ23N05W-02.6d	Gary Weyhrich	100	I	499	0.2	9.73	489.47	9.23	489.97			0.90	498.30
TAZ23N05W-04.3c	Scott Friedrich	100	I	510	0.2	36.04	474.16	36.46	473.74	32.85	477.35	27.80	482.40
TAZ23N05W-05.3c	Bob Friedrich		I	495	1.0	30.31	465.69	30.88	465.12	27.19	468.81	22.80	473.20
TAZ23N05W-06.6e	Bob Friedrich		I	515	0.4	52.91	462.49	52.75	462.65	49.75	465.65	45.98	469.42
TAZ23N05W-13.5a	Tom Smith	94	D	547	2.0	50.64	498.36	50.28	498.72	48.05	500.95	45.70	503.30
TAZ23N05W-15.3e	Bob Reed	21	D	490	1.5	12.89	478.61	12.53	478.97	10.46	481.04	6.54	484.96

Appendix A. (Continued)

Legal location	1992 Owner/operator	Depth (ft)	Use	Estimated land surface elevation (ft above msl)	Measuring Point (MP) height (ft)	Inventory: Depth to water below MP (ft)	Inventory: Ground-water elevation (ft above msl)	Fall 1992: Depth to water below MP (ft)	Fall 1992: Ground-water elevation (ft above msl)	Spring 1993: Depth to water below MP (ft)	Spring 1993: Ground-water elevation (ft above msl)	Fall 1993: Depth to water below MP (ft)	Fall 1993: Ground-water elevation (ft above msl)
TAZ23N05W-19.7g	Dan Duvall	79	I	478	1.0	7.48	471.52	7.38	471.62	6.18	472.82	4.15	474.85
TAZ23N05W-20.2f	Ron Meyer	86	I	484	1.4	6.78	478.62	6.08	479.32	5.44	479.96	3.18	482.22
TAZ23N05W-21.2b	Dale Schleders	100	I	540	0.5	52.83	487.67	53.21	488.29	50.27	490.23	47.42	493.08
TAZ23N05W-36.1d	Margaret Hankins	150	I	535	1.0	19.78	516.22	20.17	515.83	15.84	520.16	8.95	527.05
TAZ23N06W-03.7b	Ken Becker	96	I	500	0.0	43.85	456.15	44.72	455.28	41.21	458.79	38.43	461.57
TAZ23N06W-04.1g	Ken Becker		I	505	1.2	48.99	457.21	49.92	456.28	46.03	460.17	43.23	462.97
TAZ23N06W-05.6c	John Parkin		I	517	0.4	57.13	460.27	58.24	459.16	54.40	463.00	51.56	465.84
TAZ23N06W-10.3f	Ken Becker		I	495	0.5	36.78	458.72	37.50	458.00	33.83	461.67	31.24	464.26
TAZ23N06W-13.7c	Bruce Meyer		I	474	1.0	8.21	466.79	8.75	466.25	8.69	466.31	5.82	469.18
TAZ23N06W-15.1g	Bruce Meyer		I	470	1.5	9.13	462.37	9.58	461.92	8.11	463.39	8.56	462.94
TAZ23N06W-16.6f	Scott Tolbott		1	498	1.5	34.95	464.55	35.45	464.05	32.77	466.73	29.59	469.91
TAZ23N06W-17.7b	Ronald Armbrust	107	I	507	0.0			29.50	477.50	25.56	481.44	21.72	485.28
TAZ23N06W-18.3h	ScottTolbott	114	I	515	1.2			55.07	471.13	41.30	474.90	37.70	478.50
TAZ23N07W-01.2b	Ken Fornoff		I	505	0.7	45.62	460.08	47.65	458.05	43.39	462.31	40.22	465.48
TAZ23N07W-12.7c	ScottTolbott	111	I	515	1.2			54.22	461.98	49.90	466.30	46.11	470.09
TAZ23N07W-13.3d	ScottTolbott		I	515	0.0			49.26	465.74	43.59	471.41	41.74	473.26
TAZ23N07W-14.7g	ScottTolbott	124	I	515	0.0	56.41	458.59	58.57	456.43	54.79	460.21	51.98	463.02
TAZ24N05W-03.6a	ISWS (Pekin) OW8	49	OW	480	0.0	30.83	449.17	31.83	448.17	21.43	458.57	20.44	459.56
TAZ24N05W-11.6d	Steve Draber	130	D	535	1.0	91.48	444.52	92.20	443.80	89.92	446.08	85.58	450.42
TAZ24N05W-11.6h	ISWS (Pekin) OW7	105	OW	535	2.6	94.18	443.42	94.85	442.75	91.78	445.82	88.55	449.05
TAZ24N05W-14.2d	Holly Irving	65	D	519	1.6	58.79	461.81	58.80	461.80	56.58	464.02	50.60	470.00
TAZ24N05W-14.8e	Ernie Runyon	127	I	518	1.0	58.40	460.60	58.62	460.38	55.85	463.15	50.60	468.40
TAZ24N05W-16.7g	Ernie Runyon	88	I	480	0.2	34.73	445.47	44.75	435.45	40.08	440.12	37.40	442.80
TAZ24N05W-20.2b	Ernie Runyon	108	I	535	1.5	73.80	462.70	75.05	461.45	71.59	464.91	67.60	468.90
TAZ24N05W-20.7c	GroverZeeck	120	D	528	1.7	74.18	455.52	74.60	455.10	72.24	457.46	69.25	460.45
TAZ24N05W-21.2g	Ernie Runyon	126	I	515	0.4	57.05	458.35	57.98	457.42	54.41	460.99	51.40	464.00
TAZ24N05W-22.3g	Ernie Runyon		I	495	0.5	25.61	469.89	26.78	468.72	23.24	472.26	20.44	475.06
TAZ24N05W-27.7g	Ernie Runyon		I	515	1.3	44.60	471.70	45.17	471.13	41.89	474.41	37.10	479.20

Appendix A. (Concluded)

Legal location	1992 Owner/operator	Depth (ft)	Use	Estimated land surface elevation (ft above msl)	Measuring Paint (MP) height (ft)	Inventory: Depth to water below MP (ft)	Inventory: Ground-water elevation (ft above msl)	Fall 1992: Depth to water below MP (ft)	Fall 1992: Ground-water elevation (ft above msl)	Spring 1993: Depth to water below MP (ft)	Spring 1993: Ground-water elevation (ft above msl)	Fall 1993: Depth to water below MP (ft)	Fall 1993: Ground-water elevation (ft above msl)
TAZ24N05W-28.4b	Ernie Runyon	120	I	525	1.0	58.82	467.18	59.82	466.18	56.16	469.84	54.38	471.62
TAZ24N05W-29.3b	Ernie Runyon	120	I	528	1.0	62.00	467.00	64.29	464.71	59.69	469.31	55.85	473.15
TAZ24N06W-14.7e	Bob Schumm	43	I	440	0.5	6.78	433.72	7.04	433.46	5.60	434.90	5.03	435.47
TAZ24N06W-21.8a	Ed Proehl		AI	484	1.1	44.15	440.95	49.50	435.60	40.64	444.46	37.24	447.86
TAZ24N06W-22.2g	Ken Fornoff	94	I	483	0.5	44.91	438.59	47.63	435.87	41.50	442.00	41.47	442.03
TAZ24N06W-22.7a	KenFornoff		I	485	0.0	39.06	445.94	40.22	444.78	36.95	448.05	31.82	453.18
TAZ24N06W-23.2a	Ken Becker	63	I	460	1.5	24.28	437.22	24.87	436.63	19.17	442.33	13.72	447.78
TAZ24N06W-26.2a	Phillip Golden	55	I	456	0.7	4.81	451.89	4.89	451.81	3.75	452.95	2.35	454.35
TAZ24N06W-27.2b	Phillip Golden	94	I	500	0.3	51.72	448.58	53.79	446.51	49.54	450.76	45.46	454.84
TAZ24N06W-28.3f	Scott Tolbott	78	I	480	0.0	38.00	442.00	40.54	439.46	35.83	444.17	31.66	448.34
TAZ24N06W-29.2b	EdProehl		I	501	1.4	58.25	444.15	59.35	443.05	55.15	447.25	51.67	450.73
TAZ24N06W-31.1g	EdProehl	88	AI	498	0.5	47.46	451.04	52.41	446.09	46.59	451.91	40.95	457.55
TAZ24N06W-31.4c	EdProehl	99	I	506	0.0	55.63	450.37			51.55	454.45	48.84	457.16
TAZ24N06W-34.2b	Ken Becker	95	I	520	0.0	59.42	460.58	58.52	461.48	56.37	463.63	53.82	466.18
TAZ24N06W-34.7g	Ken Becker		I	520	0.5	69.96	450.54	69.89	450.61	66.02	454.48	62.68	457.82

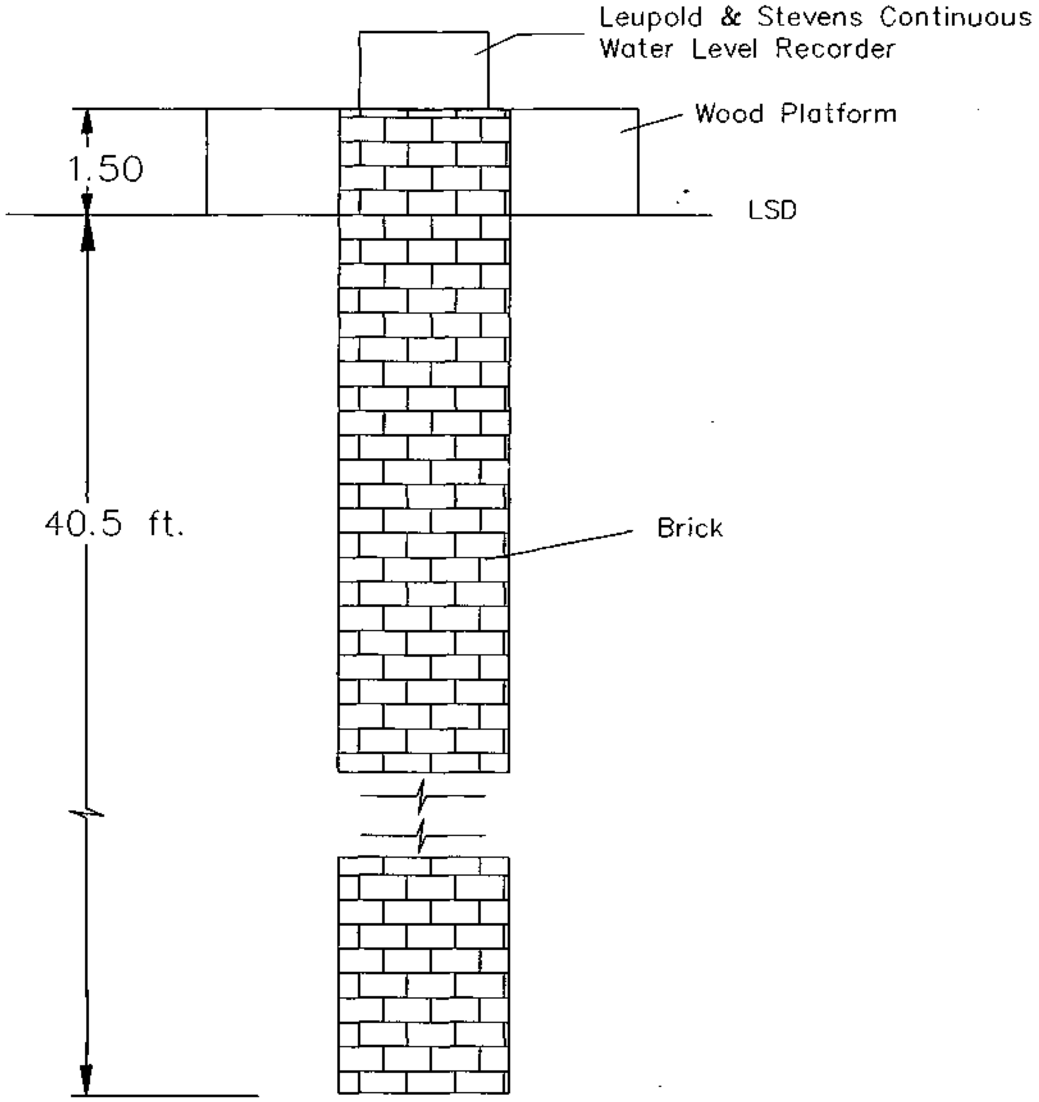
Explanation:

Negative ground-water level values indicate water level above measuring point.

I = Irrigation well
AI = Unused irrigation well
D = Domestic Well
AD = Unused domestic well
F = Farm supply well
AF = Unused farm supply well
OW = Observation Well
SW = Stream site

Appendix B.

Construction features of long-term observation wells



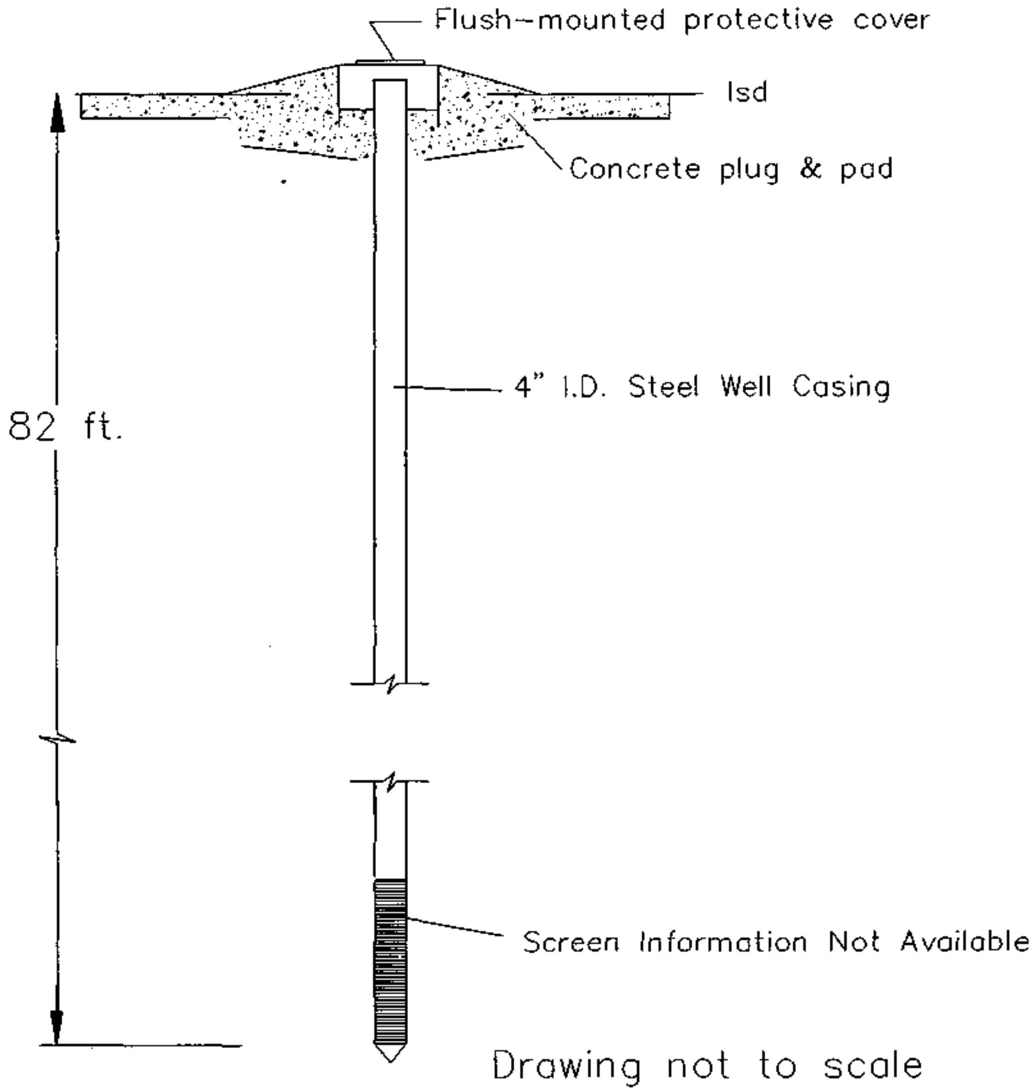
Drawing not to scale

Illinois State Water Survey Drillers Log
Section 11.8b, T.19N., R.10W., Mason County
SWS ID #00091

Depth (feet)	Description of Materials
	Log Not Available

Snicarte

Figure B-l. Construction features of observation well MTOW-1

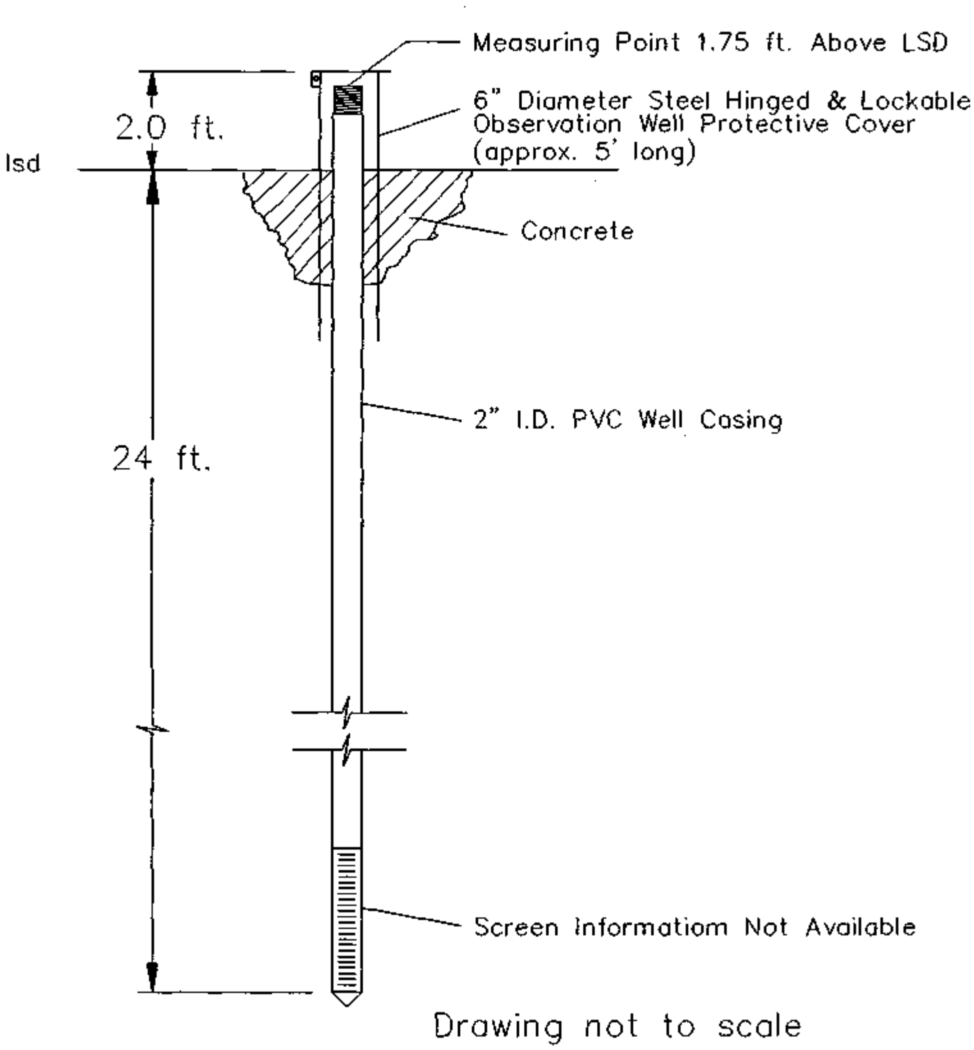


Illinois State Water Survey Drillers Log
Section 25.8a, T.21N., R.7W., Mason County
SWS Hole # N/A

Depth (feet)	Description of Materials
	Log Not Available

Easton

Figure B-2. Construction features of observation well MTOW-2

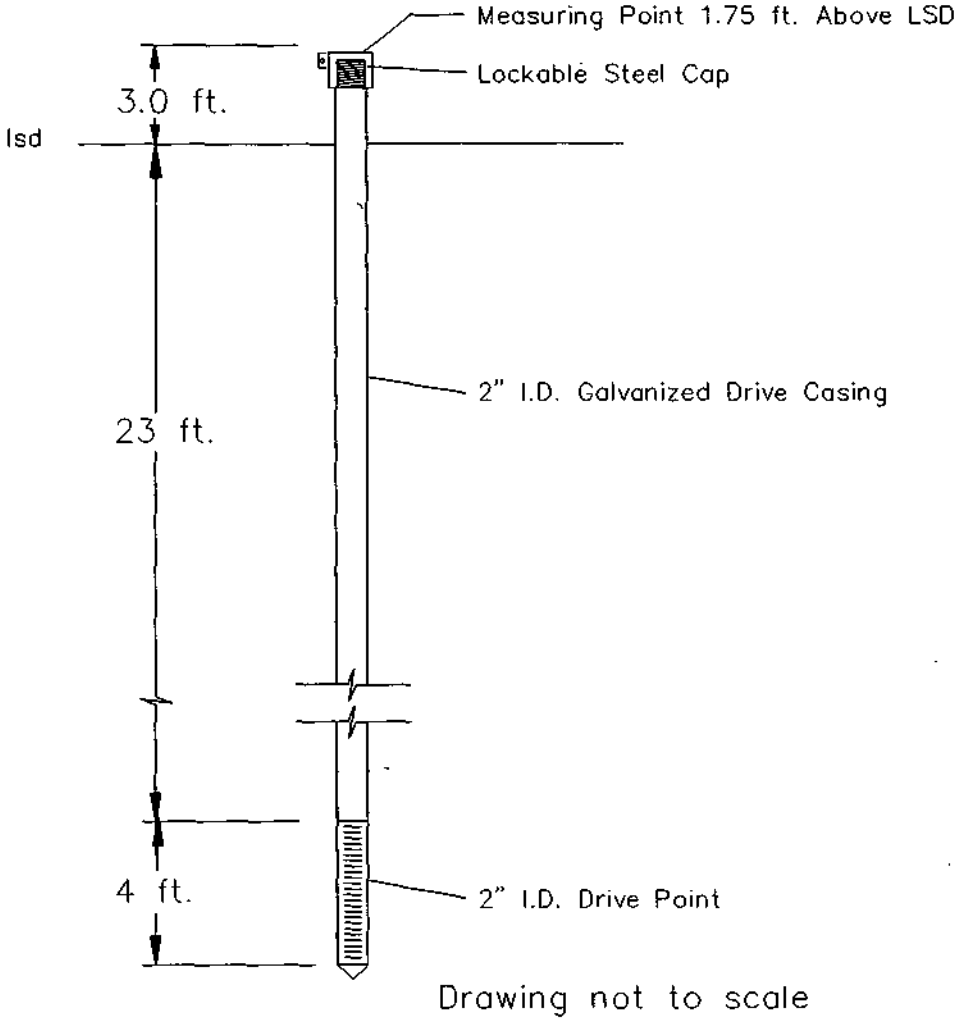


Illinois State Water Survey Drillers Log
Section 14.8c, T.20N., R.9W., Mason County
SWS Hole # N/A

Depth (feet)	Description of Materials
	Log Not Available

Mason County Wildlife Refuge
and Recreation Area

Figure B-3. Construction features of observation well MTOW-3

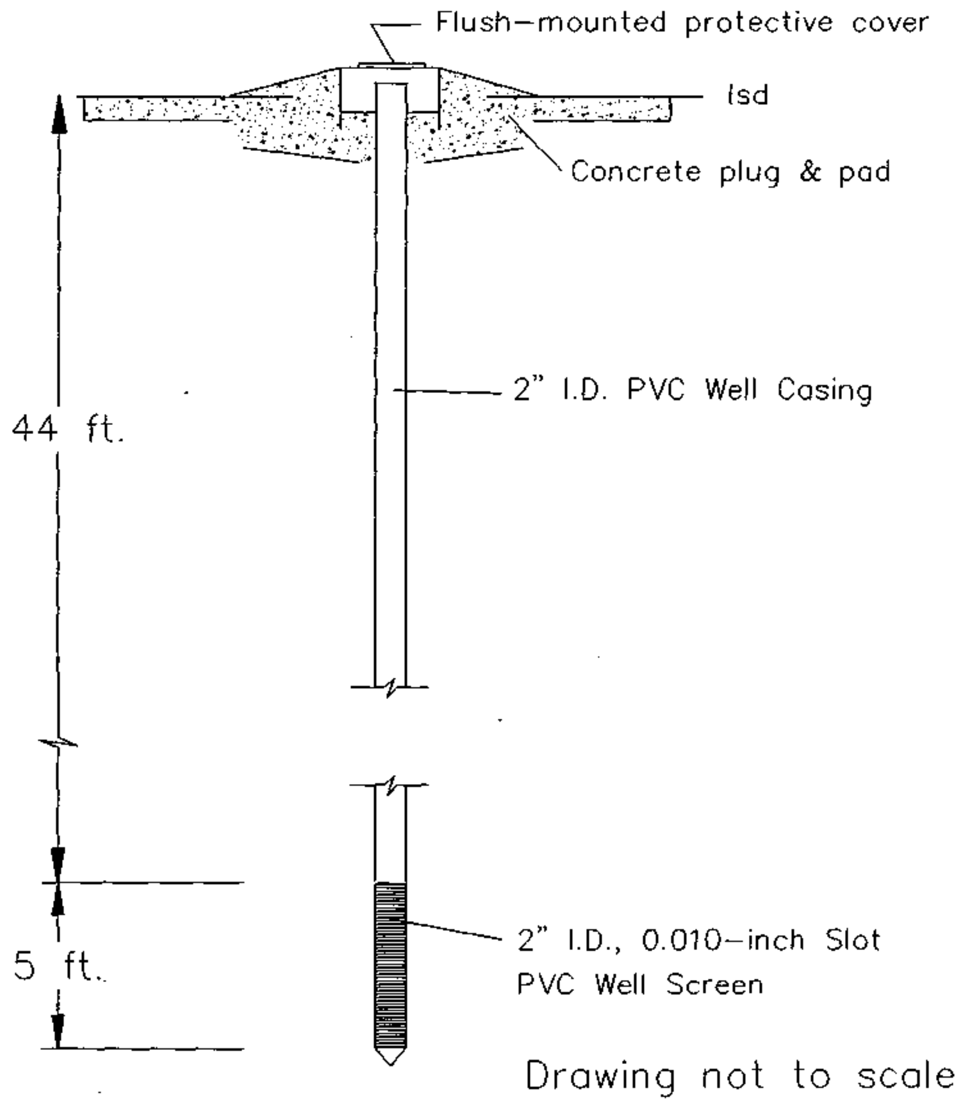


Illinois State Water Survey Drillers Log
Section 2.8d, T.22N., R.7W., Mason County
SWS Hole # N/A

Depth (feet)	Description of Materials
	Log Not Available

Sand Ridge State Forest, SR-11

Figure B-4. Construction features of observation well MTOW-4

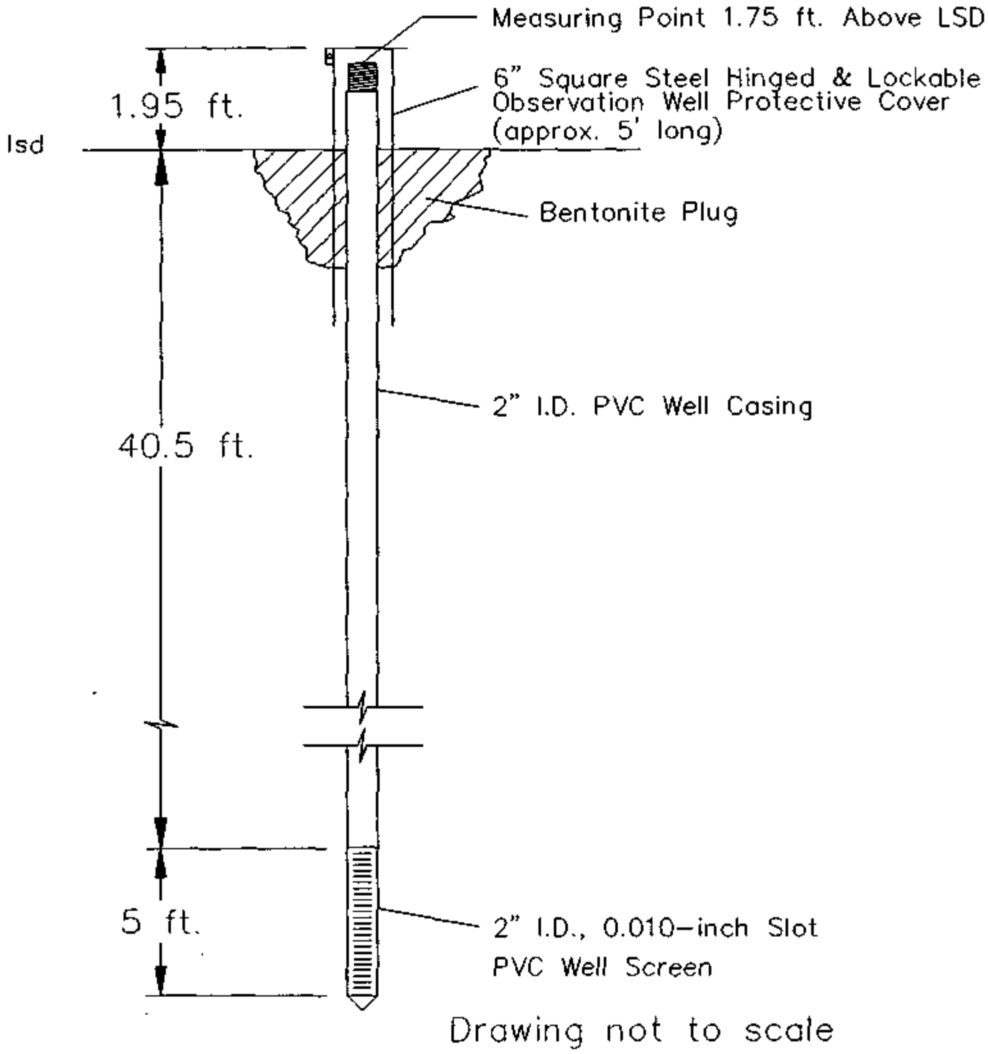


Illinois State Water Survey Drillers Log
Section 3.6a, T.24N., R.5W., Tazewell County
SWS Hole # R-196

Depth (feet)	Description of Materials
	Log Not Available

Pekin

Figure B-5. Construction features of observation well MTOW-5

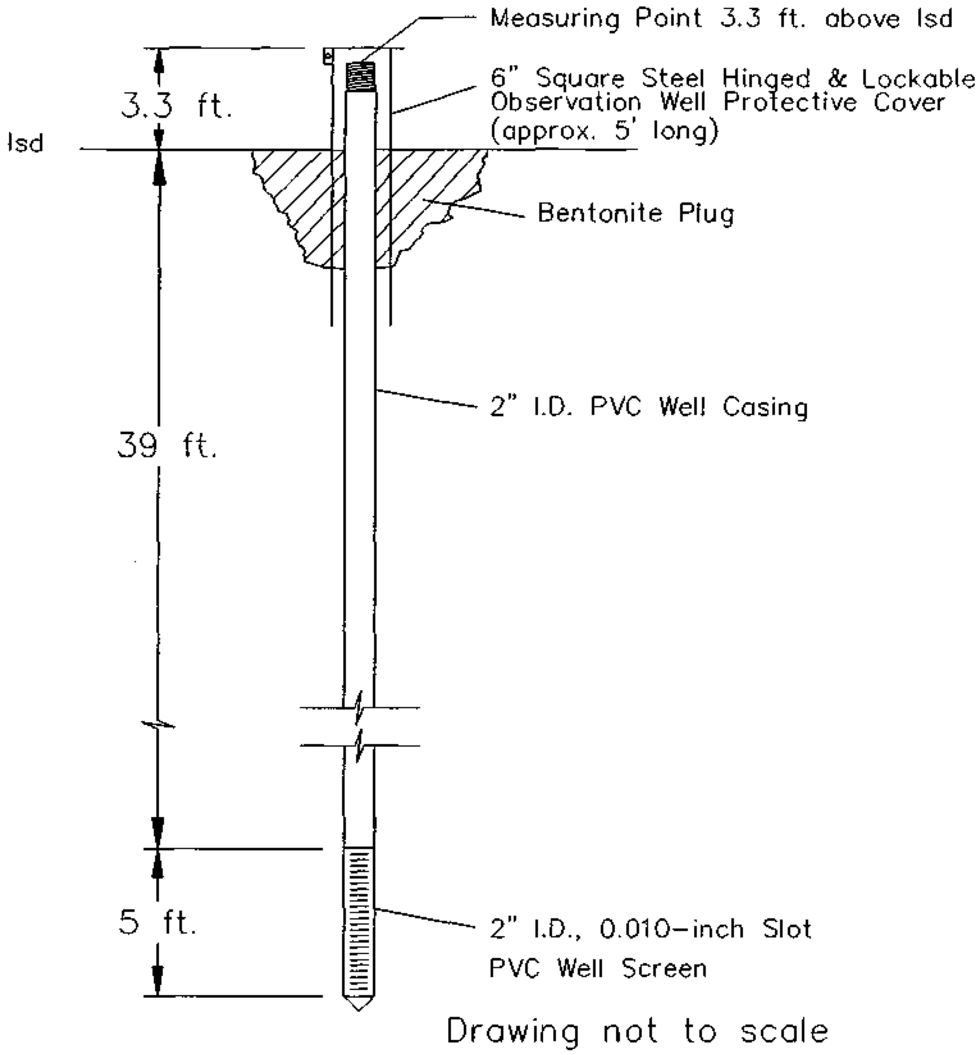


Illinois State Water Survey Drillers Log
Section 33.8f, T.22N., R.7W., Mason County
SWS Hole # R-257

Depth (feet)	Description of Materials
0-2.0	Sand, dark brown, silty
2.0-15.0	Sand, brown, medium
15.0-46.0	Sand, tan, medium to coarse

Mason State Tree Nursery

Figure B-6. Construction features of observation well MTOW-6

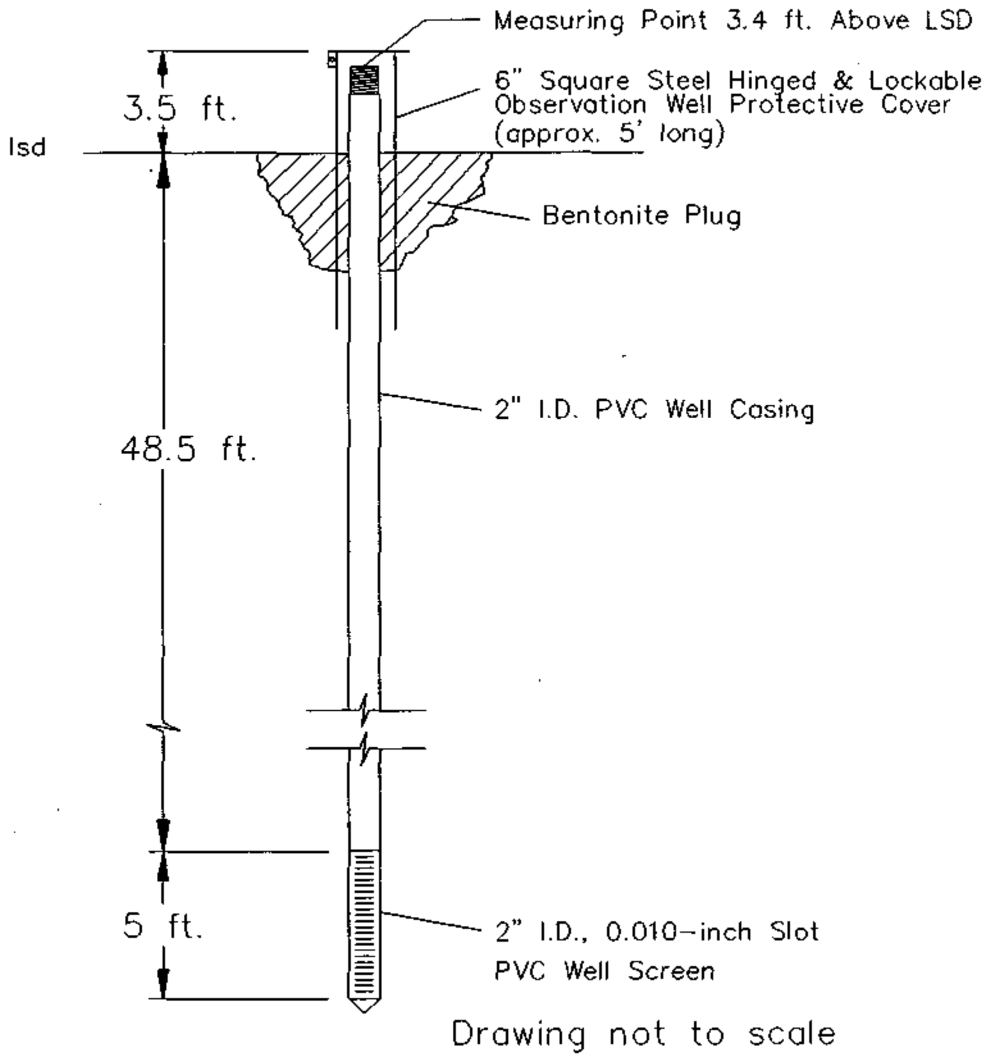


Illinois State Water Survey Drillers Log
Section 3.7e, T.21N., R.8W., Mason County
SWS Hole # R-258

Depth (feet)	Description of Materials
0-0.5	Topsoil
0.5-12.0	Sand, brown, medium to coarse
12.0-31.0	Sand, tan, medium to coarse
31.0—45.0	Sand, tan, coarse

Illinois Route 136 Rest Area

Figure B-7. Construction features of observation well MTOW-7

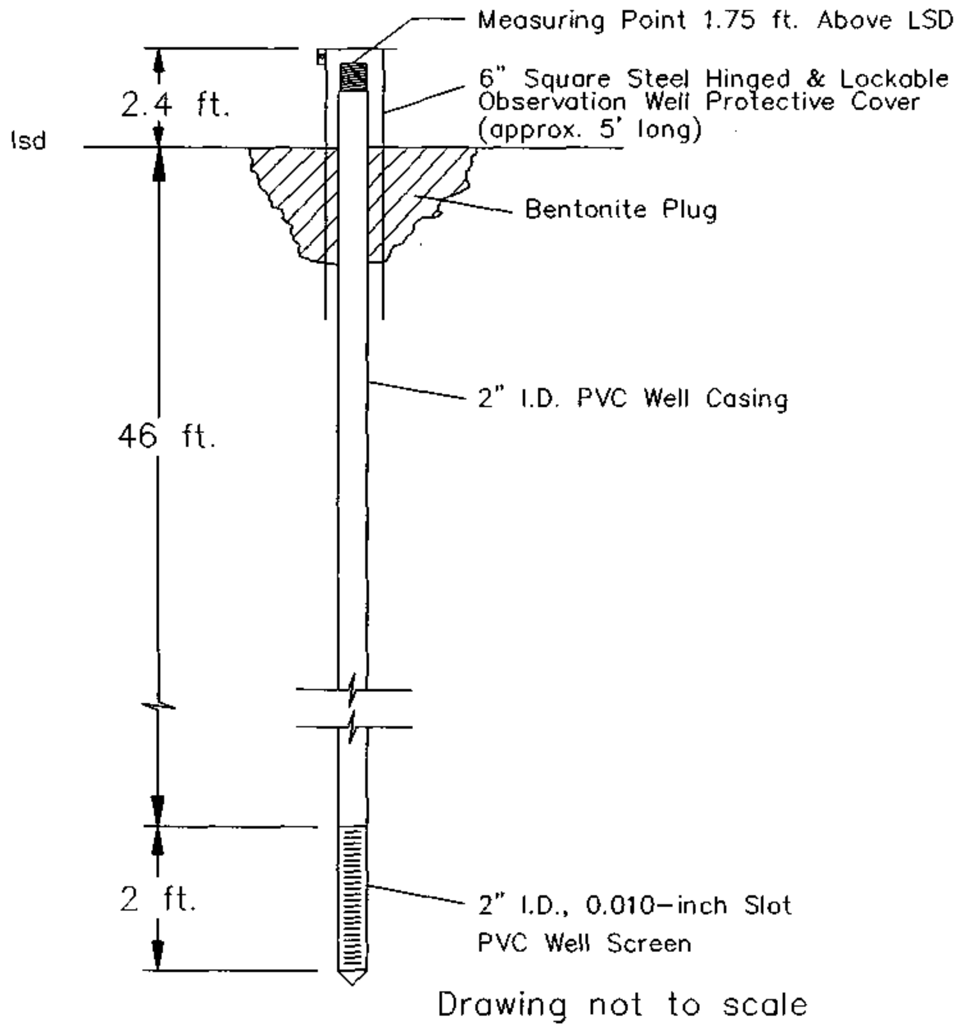


Illinois State Water Survey Drillers Log
Section 34.1c, T.23N., R.5W., Mason County
SWS Hole # R-259

Depth (feet)	Description of Materials
0-2.0	Top Soil
2.0-12.0	Clay, brown, silty
12.0-18.0	Sand, tan to brown, medium to coarse
18.0-26.0	Gravel, brown, medium to coarse
26.0—35.0	Gravel, brown, fine to medium
35.0—55.0	Sand, tan, medium to coarse

Green Valley

Figure B-8. Construction features of observation well MTOW-8

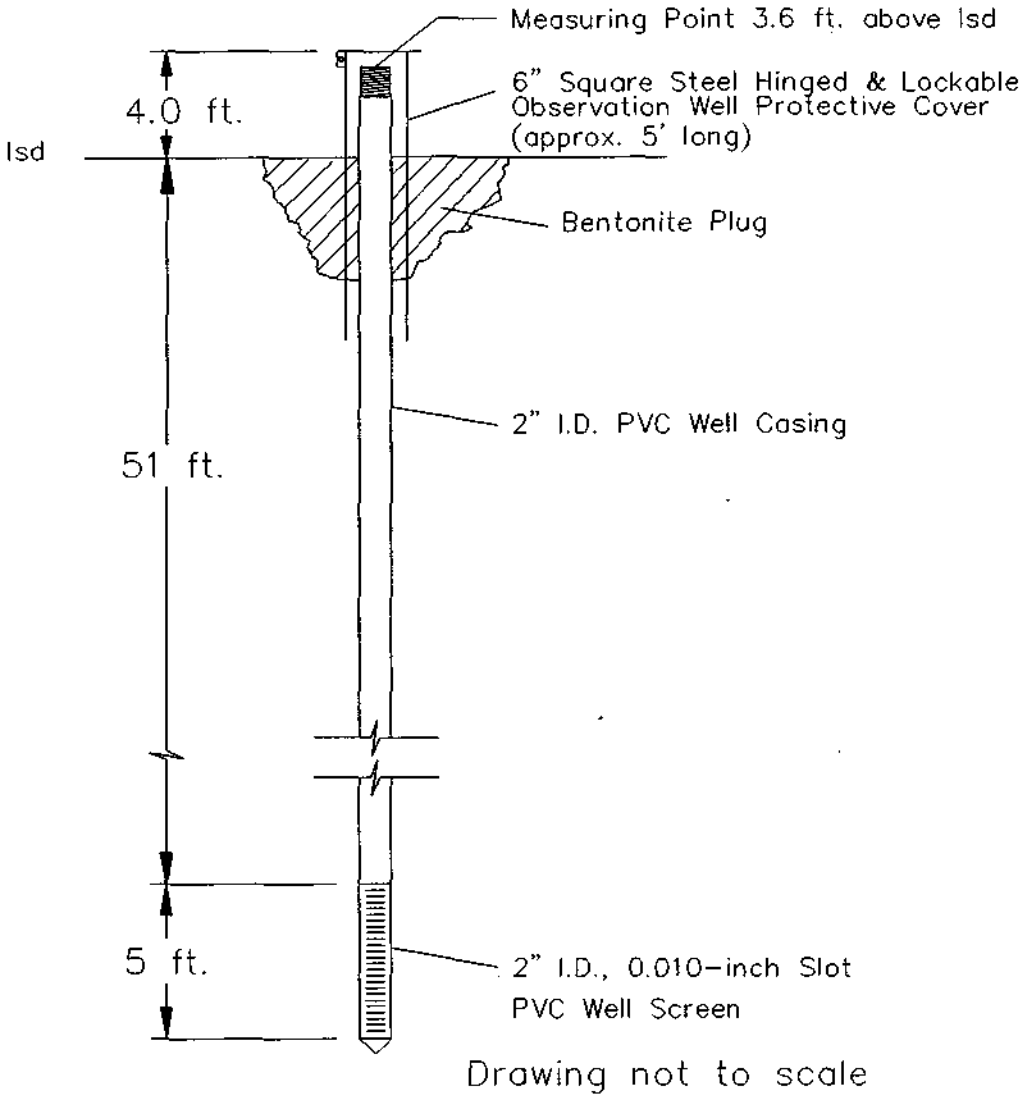


Illinois State Water Survey Drillers Log
Section 12.8e, T.21N., R.9W., Mason County
SWS Hole # R-263

Depth (feet)	Description of Materials
0-0.5	Topsoil
0.5-5.0	Sand, brown, silty
5.0—8.0	Sand, brown, medium
8.0-13.0	Sand, dark brown, clayey
13.0-55.0	Sand, brown, medium to coarse, dirty
55.0-83.0	Sand, brown, coarse
83.0-87.0	Shale, gray

Illinois Department of Transportation
Division of Water Resources

Figure B-9. Construction features of observation well MTOW-9

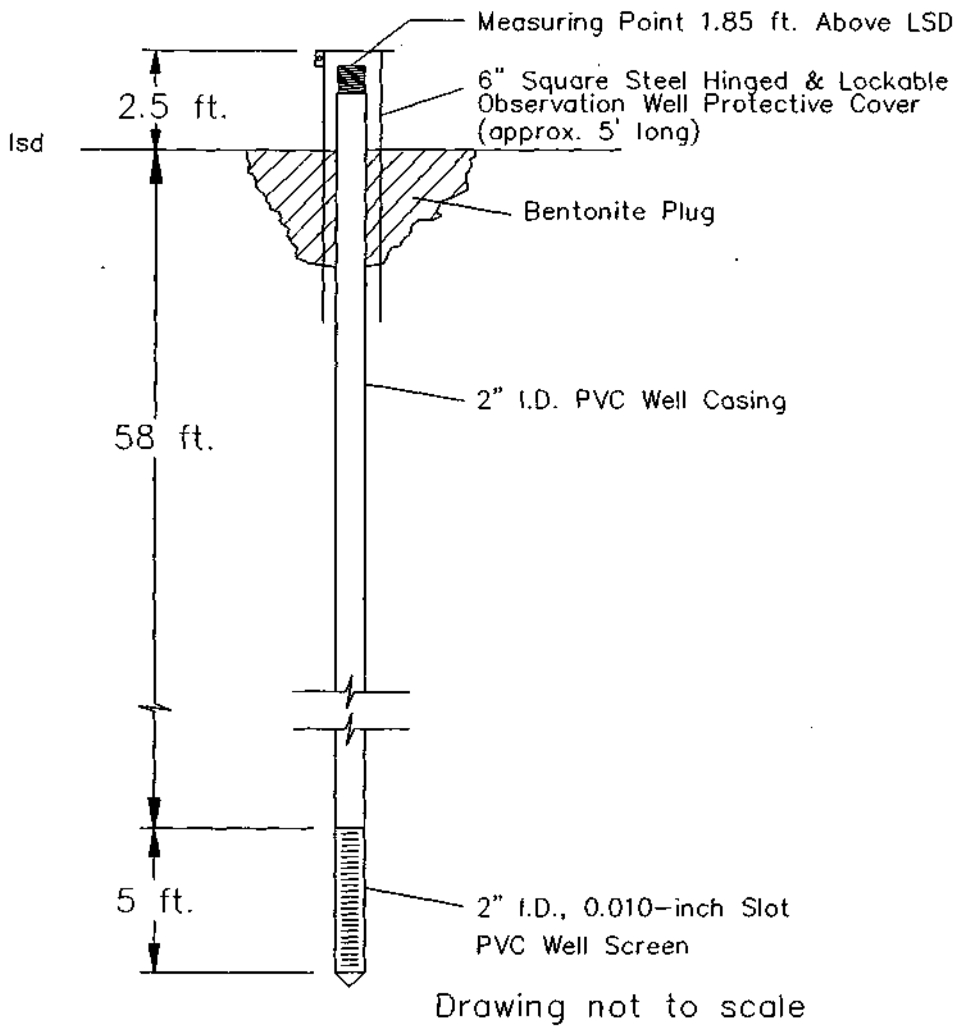


Illinois State Water Survey Drillers Log
Section 36.2d, T.22N., R.5W., Mason County
SWS Hole # R-264

Depth (feet)	Description of Materials
0-1.5	Topsoil
1.5-5.0	Clay, light brown, silty
5.0-6.0	Sand, brown, clayey
6.0-41.0	Clay, brown, silty
41.0-56.0	Sand, brown, silty

SanJose

Figure B-10. Construction features of observation well MTOW-10



Illinois State Water Survey Drillers Log
Section 18.2a, T.20N., R.5W., Mason County
SWS Hole # R-265

Depth (feet)	Description of Materials
0-1.5	Topsoil
1.5-53.0	Clay, brown, silty
53.0-58.0	Sand, brown, silty
58.0—63.0	No cuttings, probably sand, fine with silt

Mason City

Figure B-11. Construction features of observation well MT OW-11